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ABSTRACT

This publication represents the collaborative efforts of vocational educators who are involved in the planning and teaching of high technology training programs. It contains a series of reports and profiles which illustrate the diversity of high technology programs in vocational education institutions and the variety of approaches that can be used to train workers for high technology related occupations. Twenty-seven institutions that offer high technology training programs are listed, and each profile begins with the name of the program, address, telephone number, contact person, degree granted, and the year the program began. Also included are the history of the program, role of the advisory committee, the curriculum, equipment needed for the program, and faculty and placement information. Eight occupational clusters are represented: (1) biomedical (3 programs); (2) laser technology (1 program); (3) telecommunications (2 programs); (4) manufacturing and servicing technology (7 programs); (5) computer-assisted design/drafting (CAD) (4 programs); (6) computer numerical control (CNC) (2 programs); (7) robotics (4 programs); and (8) information processing (1 program). Additional miscellaneous programs described include technical writing, precision inspection, and non-destructive examination. Appendices provide information on programs impacted by technology and high technology, existing high technology programs in vocational education listed by program area and state, and a glossary of robotics terminology. (JB)

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HIGH TECH

HIGH TECHNOLOGY IN VOCATIONAL EDUCATION

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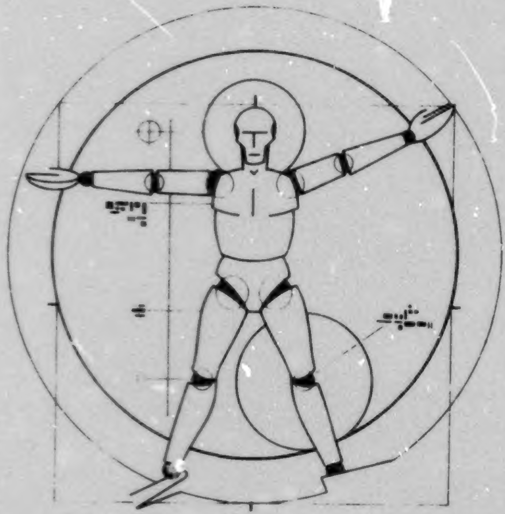

Training Programs for Emerging Occupations

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FOREWORD

This publication represents the collaborative efforts of many vocational educators who are involved in the planning and teaching of high technology training programs. Contained in this publication are a series of reports and profiles which serve to illustrate the diversity of High Technology programs in our Vocational Education institutions and the variety of approaches which can be used to train workers for High Technology-related occupations.

Each profile begins with the name of the program, address, phone number, contact person, degree and the year the program began. The history of the program, along with information about the role of advisory committees, a description of the program, the curriculum (when available), equipment needed for the program, the faculty hired to teach in the program, and placement information are all included.

Eight High Technology occupational clusters have been examined through these profiles and reports. They are:

Biomedical Occupations,
Laser Technology,
Telecommunications,
Manufacturing and Servicing Technologies,
Computer-Assisted Design (CAD),
Computer Numerical Control (CNC),
Robotics,
Information Processing, and
Miscellaneous Programs (including Technical Writing, Precision Inspection and Non-Destructive Examination).

Special thanks to those institutions who have contributed their time and ideas to this project and to the State Offices of Vocational Education who originally identified the programs.

Judith Rodenstein
Project Associate

INTRODUCTION

What is "high technology"? To some, it refers to advances and discoveries which are on the cutting edge of science. Inherent in this definition is the constancy of change with each new discovery and invention. To others, "high technology" represents the application of technological developments such as computing, micro-electronics and robotics to work and recreational activities. Regardless of the definition, it is easy to find interesting examples of high technology in all facets of life. For example,

-Microcomputer chips containing a radio are being inserted into eyeglass frames to make FM sunglasses. A similar chip will soon appear in pens and pencils. A stereo version is planned for the future.

-Recently, engineers and scientists at NASA developed a self-replicating machine. These machines are capable of producing products as well as entire factories. In Japan, there are industrial robots which actually build other industrial robots with a minimum of human intervention.

-Even natural resources are incorporating high technology applications. Computers can help trees grow. A series of programs have been developed that analyze forestry information. Foresters no longer need to spend hours calculating lumber related data or writing reports. Programs include files ranging from lumber yield tallies to investment analysis.

High technology has become so pervasive that Electromagnetic Interference (EMI) from microprocessors is becoming a growing problem. Because of EMI, pilots who tried to land at Andrews Air Force Base found their jets' guidance systems disrupted by mysterious radio signals. They found that the signals were coming from the price scanner on an electronic cash register in a drugstore near the base. In a midwestern city, emergency vehicles' communication devices were eliminated everytime they passed through a particular city block because EMI was leaking from a video arcade.

History of High Technology

In an article in the Florida Vocational Journal (1983) the development of high technology was explored. Table 1 includes a synopsis of that development.

Table 1

Year	Discoveries and Inventions
1800	Electrons and X-Rays
1900	Riode vacuum tube, oscillator, tetrode, pentode, radio, television
1930	Magnetron, radar, klystron, microwave tube, traveling wave tube
1940	Electronic computer, transistor
1960	Molecular electronics, masers, optical masers, lasers, integrated circuit chips
1980	High-speed integrated circuit chips

When integrated circuit chips became readily available at an affordable price, high technology changes began impacting every occupational and recreational area. To illustrate, in microelectonics the silicon chip affects the operation and manufacturing of all equipment. In robotics the silicon chip combined with automated machinery, results in dramatic advances in computer-assisted manufacturing. In telecommunications, the speed and quality of information flow increased with the use of fiber optics (a transmitting cable), full electronic telephone switching, and continued growth in satellite usage. Office machines which are designed around integrated circuits have become the heart and brains of the office.

The concomitant change in requisite job skills from routine tasks to those who require the ability to use computer-based machines has been equally dramatic.

The Effect on Work

The world of work has and will continue to reflect the continued changes in applied technology. This means that more and more workers will be needed for technically-oriented jobs. If workers do not heed this call, they will be gradually excluded from better-paying jobs such as those identified in Table 2.

Table 2

Jobs in 1990

Occupation	Demand	Starting Salary
COMPUTER		
Office-business info processor	270,000	$20,000
Distributive info processor	140,000	20,000
CAD engineer	450,000	14,500
CAD technician	300,000	18,000
Modeling and simulation technician	300,000	25,000
Graphics input artist	150,000	18,000
CAD parts cataloguer	125,000	11,000
CAM technician	120,000	30,000

Table 2 (Contined)

(Occupation)	(Demand)	(Starting Salary)
TECHNOLOGICAL		
Geriatric social tech	610,000	15,000
Housing rehab tech	500,000	14,000
Emergency med tech	400,000	16,000
Robot prod. tech	400,000	15,000
Laser technician	360,000	15,000
Hazardous waste tech	300,000	15,000
Battery tech	250,000	12,000
Materials util tech	210,000	15,000
Genetic engine tech	200,000	10,000
Halographic inspector	160,000	20,000
Bionic-electronic	120,000	21,000

(Table from Manpower Comments Sept 1983 p.8)

Another perspective which helps to clarify technological changes reflected in work force needs is gained by examining unemployment rates by industry (See Table 3).

Table 3

Unemployment By Industry

Industry	# of Unemployed (millions)	% Unemployed
Mining	.165	18.2
Construction	.987	18.1
Manufacturing	2.752	11.5
Durable Goods	1.730	12.2
Nondurable Goods	1.022	10.4
Transportation and Public Utilities	.399	7.8
Wholesale & Retail	2.204	10.2
Finance and Service	1.764	7.2
Government Workers	.774	5.1
Agriculture	.258	17.0

(Seasonally Adjusted Data Source: BLS, Employment Situation, June 1983)

Mining, construction and manufacturing remain the hardest hit by unemployment. Many reasons can be pointed to as causes of this problem but despite the variety of reasons, it can be assumed that these industries will never employ the same workers at previous levels of employment. One reason for this is the increased use of robots in manufacturing and construction. This s confirmed in a study completed by The Robot Institute of America (1982). The goal of the study was to forecast the future robot population. It was found that the robot population will increase from less than 4200 in 1981 to the 50,000-100,000 range by 1990. It was also predicted that between 25% and 30% of these robots will be installed in major automobile manufacturing plants.

It should be noted that automation is taking place in all industries, not just those which utilize robots. In the insurance industry, agents and brokers are using computers to perform clerical tasks such as preparing reports, maintaining records, drawing up lists of prospective customers, and planning programs tailored to a prospective customer's needs.

In the steel industry, greater use is made of computers to control plant equipment such as hot finishing mills and other steelmaking operations. The attendant can feed instructions to the automatic equipment through a card reader. The manual operation of the equipment is thus eliminated.

In the apparel industry, computers are being used to draw patterns, mark cloth for cutting, and (combined with laser technology) cut cloth. Other automation includes sewing machines that position needles and trim threads as well as removing and stacking completed pieces.

In the telephone industry, traffic service position systems automatically feed data about each telephone connection into a computer. The data includes the length and cost of a call and also billing statements which are prepared automatically. Previously this information was tabulated by an operator who then transferred it to the billing system. Electronic switching systems are also being used by the telephone companies. They eliminate the need to manually switch telephone calls.

How do these changes cause impact on the life of the worker? The General Accounting Office (1982) has accumulated data which lists many of the industries adversely affected by automation (See Table 4), in addition to those that will benefit as a result of increased automation (See Table 5)

Table 4

Industries Adversely Affected by Automation

Industrial

- Molders
- Machine Tool Operators
- Machine Set-Up Workers
- Tool-and-die makers
- Printing Compositors
- Photoengravers
- Electrotypers and Stereotypers
- Boiler-tenders
- Electroplaters
- Motion Picture Projectionists
- Photgraphic Laboratory Occupations
- Production Painters

Office

- Bookkeeping Workers
- Cashiers
- File Clerks
- Hotel Front Office Clerks
- Office Machine Operators
- Postal Clerks
- Shipping and Receiving Clerks
- Stock Clerks
- Insurance Claim Representatives and Agents
- Buyers
- Credit Managers

Scientific and Technical

- Broadcast Technicians
- Drafters

Table 5

Industries Which Benefit From Increased Automation

Industrial
- Instrument Makers (Mechanical)

Office
- Computer Operating Personnel
- Computer Programmers
- Systems Analysts
- Bank Clerks
- Bank Officers and Managers
- Accountants
- City Managers

Scientific and Technical
- Ceramic Engineers
- Chemical Engineers
- Electrical Engineers
- Industrial Engineers
- Metallurgical Engineers
- Mathematicians
- Physicists
- Engineering and Science Technicians

Mechanics and Repairers
- Business Machine Repairers
- Computer Service Techncians
- Maintenance Electricians

Communication
- Technical Writers

The Effect on Training and Education

What do these changes in industry mean to the education and training of workers in Vocational-Technical programs? Simply put, if educators want to continue to prepare students with the proper skills needed to perform in the work force, then these new job skills will need to be incorporated into the curriculum. Many states (such as the State of Minnesota) have taken the first step in implementing these changes. They have first identified their AVTI programs which will be impacted by technology and high technology (See Appendix A). It appears that the majority of existing programs will be affected by technology. From that list, administrators and instructors at the district level have started to examine local needs and the needs of industry vis a vis high technology. As a result, programs are being adapted or created which will serve as a unified response to those needs.

The Goals of This Book

This publication highlights schools that have responded successfully to these perceived "high tech" needs. The courses and/or programs will be described through a case study format so that other educators can create or adapt similar programs modeled after the examples included in this book.

Also contained in the book, are two reports which were written upon the completion of an assessment of high technology-related needs. The first, written in the state of Washington, details a systematic needs assessment procedure that was undertaken to identify resources necessary for maintaining the institution as a quality training site for those employers who wanted graduates with "high tech" skills. The second report, completed by the state of Connecticut, contains a needs survey of state employers which ecticut, contains a needs survey of state employers which served to clarify employer needs.

The programs and/or courses that are highlighted in this publication represent eight categories of high technology applications. They are:

1. Biomedical Technologies,
2. Laser Technology,
3. Telecommunications,
4. Manufacturing and Servicing Technologies,
5. Computer-Assisted Design (CAD),
6. Computer Numerical Control,
7. Robotics,
8. Information Processing, and
9. Miscellaneous Programs, including Technical Writing, Precision Inspection and Non-Destructive Examination.

Appendix B contains two lists of programs (one by program and one by state) that are in operation or under development in high technology areas. Included in that list are the name and phone number of a contact person.

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EMERGING HIGH TECHNOLOGY
OPPORTUNITIES IN CONNECTICUT

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All opinions expressed reflect the views of the author and are not necessarily those of the State Department of Education or of the State Technical Colleges Board of Trustees or of the Central Office Staff.

The complete report is 85 pages. This abridged version leaves out background and procedural material such as lists of those interviewed, questionnaires, etc. Complete copies are available on request. A bibliography is also available.

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Abstract

This report describes a study performed to determine the workforce needs of Connecticut industry, specifically as related to emerging high technology jobs. The study analyzes those needs with the objective of developing appropriate curricula for the State Technical Colleges, and with secondary objectives of identifying any secondary school preparation needed for articulation to the Technical Colleges, or to prepare secondary or vocational-technical school graduates for high technology jobs.

The study identified six high technology areas having a high potential for Connecticut's industry and workforce. A set of five options to be considered by the Technical Colleges in order to satisfy the education requirements imposed by high technology is presented. The need for the Technical College to provide th graduate with a solid base in mathematics and science, together with adequate communication and problem solving skills is emphasized. The absence of an adequate data base concerning industry's specific needs regarding a high technology workforce, either present or projected, precluded the development of anything more than general education and curricula development recommendations.

At the secondary level, the need for improvement in the basic science, mathematics and communications skills is emphasized. No significant high technology jobs that could be filled by secondary or voc-tech school graduates were found.

There is a general need for a coordinated planning effort by the various state organizations, a portion of which

would address the specific industry needs concerning education and training of the workforce.

Introduction

A. Statement of the problem

The technological revolution that is taking place today is producing worldwide changes in business and industry. Countries with inexpensive labor are becoming more industrialized, and at the same time the United States, through the application of "high technology", is changing into an information, software and service oriented society. This is not to imply that the U.S. will cease to be a producer of goods, but rather that those goods that this country continues to produce will require the application of the new technologies. The microprocessor and the computer, automation and robotics, lasers and fiber optics, genetic and bio-engineering are all examples of the myriad high technologies that have found their way into business and industry, and which are changing the skill and training requirements of our work force. Connecticut, with its high concentration of manufacturing industries is already feeling the effects of the technology revolution, and future changes will be increasingly dramatic. Although manufacturing can be expected to see continued growth, by far the largest growth is projected in the non-manufacturing areas characterized as the service, information and software ("thoughtware", according to Dr. David Birch of MIT) industries. The changes within manufacturing, and the changes in the broad non-manufacturing business areas, necessarily bring about a change in the training and skill requirements of the Connecticut workforce. There is a growing need for workers trained in the basic fundamentals of mathematics and science, and for those with knowledge and skills in the new technologies.

An appropriately trained workforce is one of the most frequently mentioned incentives for attracting high technology industry to an area.

This study looks at the projected needs of Connecticut business and industry in relation to the changing and emerging technologies, and attempts to characterize the workforce in terms of new skills and training that will be required. By developing the requisite training and education programs, Connecticut can benefit its citizens three ways:

Its workforce will be prepared to fit into the high technology era.

Connecticut business and industry will have available a trained workforce.

A workforce trained in the new technologies will help to attract new industries, and will help to retain those already in Connecticut.

Rationale

1. In order to determine the education and training needs of Connecticut's workforce as influenced by emerging and high technology, the following steps were followed:

First, information existing in and being developed by the various departments within the State government, including the Governor's office was obtained and analyzed.

Second, plans, projections and requirements of Connecticut's industries, as available, were reviewed.

Third, participation in a number of high technology workshops and seminars took place.

Fourth, a search of the literature, including technical and professional reports and journals and the popular press was conducted.

Fifth, a survey of the efforts of other states in addressing the needs of high technology industry in terms of educational facilities and a trained workforce was conducted.

Sixth, selected case histories of efforts by educational institutions in several other states were reviewed and analyzed. These institutions studied the high technology workforce needs of individual industries and resulted in the development of specific education and/or training programs designed to meet these needs.

Seventh, discussions with educators, including the Presidents, Deans, and Staff of the five State Technical Colleges and faculty members of colleges and universities were conducted.

Eighth, meetings and workshops of the Regional Councils and of the Technical Advisory Committees of the five State Technical Colleges were conducted.

2. The above related steps resulted in the selection of six key high technology areas considered to have the greatest potential for employment in Connecticut, and from these was derived a set of emerging job titles.

3. Finally, proposed educational program areas designed to meet the needs of the newly identified jobs are presented for consideration by the education community.

Goals and Objectives

The goal of this project is to determine the workforce needs of Connecticut industry regarding high technology jobs, and to develop the education and training programs that will satisfy these needs.

The objectives of this project are to:
1. investigate the state's emerging job classifications in high technology and identify the skills needed for such jobs
2. specify the kinds of education and/or training required
3. propose and design appropriate curricula for the State Technical Colleges in selected high tech areas
4. identify any additional secondary school preparation needed for articulation to the State Technical Colleges
a. identify, if possible any high technology jobs that could be filled by secondary or voc-tech school graduates
5. complete a final report for dissemination.

Although resource limitations required that the focus of this study be chiefly on the State Technical Colleges, this does not preclude the application of much of the findings to other post-secondary institutions in Connecticut, namely the Community Colleges, the State Universities, the University of Connecticut, and to the private educational institutions.

High Technology Defined

Most of the literature seems to define "high technology" in terms of examples of activities or of products, e.g., "high technology involves robotics, lasers, CAD/CAM, and computers", or "it produces microprocessors and satellite TV".

The Massachusetts Department of Manpower Development chose to use the definition of a "high technology industry or business" as "one in which a significant proportion of the workforce consists of scientists, engineers and/or technicians" (Ref. 1.). A survey of the Massachusetts durable goods industries for 1974 and 1977 showed that 13.7% of the employees were engineers, scientists and/or technicians, and this figure then became the criterion. Any business or industry with 13.7% or more of its workforce employed as engineers,scientists or technicians is classified as a high tech industry. In reference 2., the Connecticut Department of Labor presents a list of high tech manufacturing industries that apply to Connecticut, together with SIC (Standard Industrial Classification) Codes. An important addition to the Masachusetts list is "Transportation Equipment" to include the boat, ship, aircraft and spacecraft industries. Reference 3. is a State Department of

Education memorandum with a partial listing of high tech industries in Connecticut, together with lists of firms within the labor market areas.

Although the "high tech industry" classifications used by Massachusetts (ref. 1.) and Connecticut (refs. 2. and 3.) are useful, care must be used in establishing both the numbers and types of "high tech jobs", as opposed to jobs in industries classified as high technology. By counting jobs in high tech industries (which would include custodial workers, etc.) the estimate of high tech jobs is much too high. On the other hand, the Connecticut lists of manufacturing industries included in refs. 2. and 3., omit many non-manufacturing industries that employ a significant number of high tech workers (e.g. computer programming services (SIC 737), and engineering and architecture services, (SIC 8891). One final caveat to be observed when establishing a definion of "high technology industries" is the importance of including industries and fields that may employ relatively few high tech employees today, but may be projecting increasingly high rates of high tech job growth in the next few years.

Definition - In this report, high technology is defined as technology that requires knowledge and skill of a broad and/or in-depth nature, usually acquired through formal post-secondary education in mathematics, science and/or engineering.

A definition that applies to industries is (ref. 4.):
Technology-based industries
--those that produce new products resulting from technological innovation
and/or
--those whose processes are significantly affected by the application of new technologies to new or existing products.

Project Design

Target Population

This project is designed to provide recommended curricula changes to the State Technical Colleges based on a survey of high technology trends and Connecticut industries' current and projected needs. Although resource limitations restricted the focus principally on the State Technical Colleges application of some of the findings of this study to Local Education Agencies, Regional Vocational Schools, Community Colleges, State Universities and the University of Connecticut is not precluded.

Techniques and Methods

Based on an extensive literature search, about 50% of which is listed in the annotated bibliography (Appendix H), interviews with State of Connecticut government and education officials, and on participation in workshops and seminars, a matrix of 14 high technology areas versus 38 academic subjects and topics (Appendix A) was prepared. Using a modified DELPHI approach, individual workshops and surveys were conducted with the Regional Councils of the five State Technical Colleges. A questionnaire (Appendix B) was used as part of the surveys to determine those high technology areas that hold the greatest potential for Connecticut industry. A follow-up mailing was used to insure maximum response. A set of charts showing the relative importance attributed by the Regional Council members of each of the 5 technical colleges to the technology areas is included as Appendix C. For comparision, on the individual charts for each college, the list of six high tech areas, together with a list of proposed hi-tech job titles and associated academic topics and subjects, (Appendix D) was prepared for use at individual workshops with the Technical Advisory Committees at the five State Technical Colleges. In addition, a questionnaire (Appendix E) was developed, and from the workshops and the returned questionnaire, a list of high technology job titles believed to be most important to Connecticut industry's technological needs in the next five years was derived (Appendix F).

(Appendices B, C, D, E, are not included in the abridged version.)

Finally, at a meeting with the Dean's of Instruction (or their respresentatives) of the five State Technical Colleges, the recommendations for proposed curricula changes and additions were developed (Appendix G).

Surveys - In order to accomplish Section III-C, Objective 1., "To investigate the State's emerging job classifications in high technology, and to identify skills needed for such jobs", it was originally planned to survey those major industries in Connecticut that might account for the bulk of the new high tech jobs. A study of Connecticut Department of Labor data (ref. 2) does not provide a breakdown of current "high tech" jobs, since there are substantial aggregations on the one hand, and exclusions on the other. For instance, under the high tech industry listings it is not possible to determine if any of the electrical and electronic technicians enumerated are indeed filling high tech jobs, or how many. Additionally, some industries excluded from the high tech list may truly employ technicians in high tech jobs. A survey of the type needed to establish a true baseline for high tech jobs in Connecticut, and for realistic projections into the future, is urgently needed. However, such a survey is a major under-taking. Dr. David Birch of MIT (ref. 8) found that on a nationwide basis two thirds of the net new jobs were created by firms with 20 or fewer employees, and 80% were created by firms with 100 or fewer employees. Therefore, a valid survey would include thousands of Connecticut firms in order to achieve a proper coverage of the population.

The "Directory of Connecticut Manufacturers" (ref.9.) lists over 7,000 manufacturing businesses alone; service and software businesses would add significantly to the total number to be surveyed.

The resources available under this project did not allow for even a cursory survey of the scope actually needed, so only a handful of industries were contacted, more as a validation of the findings and conclusions that had emerged from the literature search and from the workshops with Technical Advisory Committees and the Regional Councils at the five State Technical Colleges.

Summary

A. Findings

1. Review of information supplied by the various Departments within the State government, and from the planning documents that address high technology in relation to educational needs within our State provided much background information of a broad and general nature. However, no studies were found that provide the specific detailed information that would have established a baseline for this project--namely, the detailed current high technology employment in Connecticut, nor any detailed projections of either new types of jobs, or numbers of jobs. Neither surveys of industries classified as high technology (Refs. 2. and 3.), nor data that list employment projections only by traditional job titles, e.g. "mechanical engineering technicians" (Ref. 11.), provide the detailed high technology workforce information required by this study.

A study providing the detailed information concerning Connecticut's high technology employment needs and projections would require extensive effort, and should be a cooperative effort involving the governor's office, and the Departments of Labor, Economic Development, Education, Higher Education and the Office of Policy and Management.

In September of 1983 Governor William O'Neill plans to initiate a new project, "Jobs for Connecticut's Future", designed to investigate the long-term needs of Connecticut's workforce, including required education and skills. Plans call for the project to be completed in one year, and hopefully, the results will provide the state's educators with information needed for high technology curriculum development.

In a December of 1981 report, the Connecticut Business and Industry Association stated "Advanced technology industries are attracted to an adequately trained workforce, by areas of centralized scientific research activities, by availability of educational institutions prepared to train, retrain and upgrade workers, and by a political climate that encourages business growth through incentives and tax restraint. Connecticut needs positive programs in all these areas, and the Boards of Higher Education, the Connecticut Academy of Science and Engineering, the governor and the legislature, the Department of Economic Development and Connecticut Product Development Corporation all need to participate" (Ref. 12.).

Some of the other states that are leaders in the development of coordinated programs to hold and attract high tech industries are Georgia, North and South Carolina, Louisiana, Texas, Minnesota, New York (Ref. 4.), Massachusetts (Ref. 5.), Michigan (Ref. 6.), and Pennsylvania (Ref. 7.). Some writers claim that a high tech core industrial area such as "Silicon Valley" in California or "Route 128" near Boston is necessary to attract high tech industries. Some claim that world class universities with top level research programs are a necessity. Connecticut does not have these. However, it does have a large concentration of industries, many of which already are high tech industries. In addition, Connecticut has a full spectrum of educational institutions, private and public, that could with proper leadership, management and support, provide a workforce well trained to meet the needs of the high tech industries, present and future.

In January of 1982 the "Governor's Blue Ribbon Committee on Higher Education and the Economy" stated in their report "Connecticut lags years behind other states in the development of long-range planning, budgeting and management information systems" and recommended "that a comprehensive management, and budgeting process be established based on a 5 year cycle and updated annually" (Ref. 13.). The Committee, in their recommendation No. 12. called for the annual appointment by the Governor of a Committee on Technological Change, to identify and report on technological change and its effect on employment opportunities in Connecticut. Recommendation No. 13. called for the governor to request the Connecticut Academy of Science and Engineering to create a committee to determine what areas of technology with high-growth potential are appropriate to Connecticut. In recommendation No. 14., the Committee suggested that the governor request the Connecticut Academy of Science and Engineering to establish a clearinghouse for information concerning scientific research projects being conducted at higher education institutions in Connecticut. If these recommendations have been implemented, valuable background information could have been available for use in our study.

A coordinated effort, starting with the governor's office, and supported by the legislature, is needed to bring Connecticut into competition with other states that have taken the lead in the high tech race. In January of 1983, Governor O'Neill established a High Technology Council. Hopefully, this Council will provide the focus and direction needed to bring Connecticut into a leadership position in this age of high technology (Ref. 20.).

Since today's technology is undergoing rapid growth and evolution, any study concerning technology's impact on the training and education requirements of Connecticut's workforce will necessarily become quickly out of date, and would require frequent revisions.

2. A broad literature search provided not only helpful general information concerning high tech jobs, job growth and education and training needs, but provided enough information from which a baseline was prepared in the form of a matrix (Appendix A). The matrix consists of 14 high tech areas versus 38 academic subjects and topics and was used, together with a questionnaire (Appendix B) in a series of workshops conducted with the Regional Councils at the 5 State Technical Colleges. Additional input was obtained from industry, from educators and by attending high tech workshops and seminars, as outlined in Section IV.

Analysis of over 200 documents related to technology, employment, and education and training shows that a wide spectrum of opinions exists, ranging from highly optimistic to very pessimistic. 109 of the documents reviewed, together with a short summary, are included in an annotated bibliography, (Appendix J); the summaries pertain only to those portions of the documents that relate to the theme of this study, and not necessarily to entire documents. In general, publications written by or for business, industry and technologists tended to be optimistic, e.g. "greater productivity", expanding markets", "more and better jobs", while labor oriented publications emphasized "loss of jobs" and "more boring and demeaning jobs". To put things in perspective, both views concerning jobs have some basis in fact. Conventional job lost due to technological advances are not necessarily transferred on a one-for-one basis into high tech jobs, but in many cases there will occur a significant job displacement. In other cases the new technology will simplify the job's skill level, i.e. "deskilling" occurs, and the job is reclassified at a lower level. Some classes of jobs will disappear almost completely, while others requiring greater technical skills will be created in substantial numbers. Not only will the newly emerging workforce need to be trained and educated in the advanced technologies, but due to the "skill shift" and "deskilling" there will be a need to retrain the displaced workers to fill the new jobs at the higher skill levels. In fact, because of the rapid and extensive technological advances, some workers can expect to become displaced and to require additional training several times during their work careers.

Since many of the high technology jobs are in the process of evolution or development, information concerning job requirements, job descriptions and required enty level skills is incomplete and in a state of flux. This presents a problem to the academic community which is attempting to develop and put into place new or updated curricula, but without an adequate information base concerning specific needs. There is, therefore, a need for the academic community to work closely with the high technology industries, not only to determine the specific education and training needs, but in some cases to work out a cooperative effort in the education and training function itself. The literature contains case histories in which such cooperative efforts resulted in successful training programs to meet the new technological requirements (Refs. 14., 15., and 16.). In some cases, an industry that is introducing a new technology into its operations will look to a local academic institution for advice and guidance concerning educational needs for the emerging high tech jobs.

The capabilities of two year technical and other colleges are expected to fall far short of meeting the projected demand (Ref. 17.), and as the technological revolution gains momentum, industry will need to provide training in areas where the traditional education system falls short. Indeed, there are examples where this is already taking place.

Those who fear that large scale unemployment will result from the efficiencies in production due to high technological advances, need only to look back to the development of the mass production of the automobile. The "high technologies" of the internal combustion engine, the vulcanization process for rubber and mass production techniques were combined to produce a useful product with a mass market demand. Stable boys became service station attendants; drovers became truck drivers; and wheelwrights, harnessmakers and wagonmakers became production workers in a huge worldwide industry. In the technologies that combined to mass produce the automomboile.

3. From the workshops conducted with the Regional Councils of the 5 State Technical Colleges, namely Greater New Haven State Technical College (GNHSTC), Hartford State Technical College (HSTC), Norwalk State Technical College (NSTC), Thames Valley State Technical College (TVSTC) and

Waterbury State Technical College (WSTC), together with answers to the questionnaire (Appendix B) and by use of a modified DELPHI approach, the following list of 6 technology areas with the best potential for high technology jobs in Connecticut was produced:

a. Computing Technology
b. Management Systems and Office Automation Technology
c. Industrial, Manufacturing, and Production Technology
d. Communications, Information Transfer and Entertainment Technology
e. Medical and Health Technology
f. Bio-engineering Technology

Although "Military Research and Development" was included in the original list of 14 technologies in the matrix, it is not a technology area, but encompasses a number of technologies. In importance it was rated just below bioengineering. "Material and Inventory Handling" technology appeared as a separate item on the matrix. However, it was suggested by Council members that it be combined with "Industrial, Manufacturing, and Production Technology". Charts showing the relative importance assigned to the technology areas by the Regional Councils of the 5 State Technical Colleges are included as Appendix C.

4. A list of proposed job titles, together with suggested academic subject areas was proposed for the 6 potential high technology areas (Appendix E), was presented at individual workshops conducted with the Technical Advisory Committees at the % State Technical Colleges. The purpose of these workshops was to develop a realistic list of emerging job categories, together with education and training requirements. Appendix F shows the relative ranking of the top 9 high tech job categories deemed to be most important in Connecticut industry. Almost 50% of the Advisory Committee members answering the questionnaire selected "Computer System Technician" as a job category with great potential, followed by the "Biomedical/Biochemical/Bioengineering Technician" category (37%), "Industrial/Manufacturing/Production Technician" category (33%), and "Electromechanical/Robotics/Automation Technician" category (26%). Other categories were selected by 15% or less of the participants.

5. The Technical Advisory Committee workshops and the earlier Regional Council workshops brought into focus several problem areas that impact on any significant changes or additions to the Technical College curricula.

a. Graduates of secondary schools need a much better foundation in math, science and communications skills for articulation to post-secondary school curricula that are geared to meet the high technology needs. This would eliminate the need for time spent on remedial work at the post-secondary level.

b. The technicians of tomorrow will need to become knowledgeable in a number of interacting technologies, and throughout their careers will need to continue to update their education as technology evolves. Therefore, it is imperative that the technical colleges provide a broad and solid foundation in science, math and technical communications skills. Consequently, when a technology area is added, e.g., electrical engineering or manufacturing technology, there is very little room left in the two year curriculum in which to add additional courses that will provide the technological scope required of the "high technician". At a presentation to the American Vocational Association Conference "Preconference Workshop" in 1982 (Ref. 18.), Dan Hull stated that what is needed is a "super tech" who can install, operate, maintain and repair systems that may incorporate combinations of electrical motors, digital circuits, mechanisms, hydraulic actuators, lenses, light sources and transducers. Emphasis will be on SYSTEMS orientation".

c. With the two year curriculum filled and little room left for additional courses, the following options were propossed.

(1) A three year associate degree program, in which the third year is devoted to one or more additional technology areas.

(2) An alternating work-study (co-op) program, in which the colleges arrange with specific cooperating industries for alternating periods of work and study, thereby working in an additional technology area over a period of three and one-half years.

(3) Continue the present Technical College two-year associate degree curricula as they now exist, with only minor modification. In addition, establish a set of high technology option to be offered to associate degree graduates as the demand arises. This, in effect, would fulfill the continuing need for technicians to keep up with technological advances. These courses would be scheduled so technicians, and in many cases the employing firms would provide tuition support and/or time off.

(4) A fourth option that would require longer lead time and cooperation and coordination at the secondary school level would be the establishment of a 2 plus 2 program. During the 11th and 12th grades those students electing the 2 plus 2 program would complete their technical math and basic science requirement, thereby freeing up 12 quarter hours at the college level. These 12 quarter hours plus 6

quarter hours presently allocated to electives would provide the room for a second technology option at the college level. An added requirement at the secondary level would be increased emphasis on the development of communications skills.

(5) A fifth option would require upgrading an existing curriculum, replacing electives with additional math and technical topics. An example is shown in Appendix G., a Computer System Technology Curriculum proposed by Thames Valley State Technical College.

d. As stated earlier, there is a growing need for retraining and upgrading the skills of workers who have been displaced by technological innovations, or those who desire to advance into the jobs requiring some technical training at the post-secondary level. There is, therefore a concommitant requirement to provide a spectrum of courses in the emerging technologies at the technical colleges, ranging from short, fast responses courses to in-depth courses on a single technical topic. Close liaison with local industry is important in order to meet specific needs in a timely manner. This capability basically already exists at the State Technical Colleges. A rapid response to the needs of industry and to displaces workers is a must.

6. Workshop with Deans of Instruction

a. At a meeting of the Deans of Instruction of the five technical colleges, the options presented in section VA5c. above were discussed. In addition, the following list of emerging job titles developed previously at the Technical Advisory Committee workshops were discussed in order to explore the feasability of developing completely new high technology programs.

--Computer System Techniciam
--Computing Technology Technician
--Manufacturing System Technician
--Robot Technician, Electromechanical Technician
--Biomedial or Bio-engineering Technician
--Management Systems Technician
--Waste and Environmental System Technician

b. It was generally agreed that although the options proposed in section VA5c. were possible solutions to the need for education of the high technician, only option (2), the alternating work-study proposal; option (3), the present curricula (modified slightly) with the addition of third year options; and option (5), elimination of all electives and upgrading selected existing programs would be practical to consider in the near term. Even option (2) would require enlisting the cooperation of selected industries and would present problems of scheduling courses to lock in with the students' work-study schedules. Option (1) met with very little enthusiasm, while option (4), although considered attractive, requires considerable planning, co-operation and lead time.

c. Although detailed job descriptions and entry level skill requirements have not been developed for the emerging job categories (for the reasons previously discussed), the following listings of suggested program areas, together with Classification of Instructional Programs (CIP) number, are provided for guidance to future studies.

(1)--Computer Systems Technician
--Computer Technolgy Technician

CIP#	Suggested Program Areas
11.0101	Computer & Imformation Science, General
11.0301	Data Processing
11.0401	Information Sciences & Systems
11.0501	Systems Analysis
14.0901	Computer Engineering
15.0301	Computer Technology
15.0402	Computer Servicing Technology

(2)--Manufacturing System Technician
--Production System Technician
--Industrial Engineering Technician

CIP#	Suggested Program Areas
06.0403	Product Management
06.0404	System Efficiency Analysis
14.1701	Industrial Engineering
14.1801	Materials Engineering
14.2001	Metallurgical Engineering
15.0404	Instrumentation Technology
15.0601	Chemical Manufacturing Technology
15.0602	Food Processing Technology
15.0603	Industrial Technology
15.0604	Manufacturing Technology
15.0607	Plastic Technology
15.0607	Welding Technology
15.0702	Quality Control Technology
21.0107	Manufacturing/Materials Processing
40.0701	Metallurgy
41.0303	Metallurgical Technology
48.0501	Precision Metal Work, General
48.0508	Welding, Soldering, Brazing

(3)--Electromechanical Engineering Technician
--Automation Engineering Technician
--Robot Technician

CIP#	Suggested Program Areas
06.0403	Product Management

11.0201	Computer Programming
14.1701	Industrial Engineering
15.0304	Laser Electro-optic Technology
15.0603	Industrial Technology
15.0604	Manufacturing Technology
15.0610	Welding Technology
15.0702	Quality Control Technology
15.0805	Mechanical Design Technology
15.0699	Industrial Production Technology (Other) (Robotics)
21.0107	Manufacturing/Materials Processing
41.0303	Metallurgical Technology
48.0501	Precision Metal Work, General
48.0508	Welding, Soldering, Brazing

(4)--Bio-medical Engineering Technician
--Bio-engineering Technician

CIP#	Suggested Program Areas
14.0501	Bioengineering and Biomedical Engineering
15.0401	Biomedical Equipment Technology
15.0404	Instrumentation Technology
17.0203	Electrocardiograph Technology
17.0204	Electroencephalograph Technology
17.0209	Radiograph Medical Technology
17.0212	Ultrasound Technology
17.0309	Medical Laboratory Technology
17.0311	Microbiology Technology
18.0201	Clinical Anatomy
18.0202	Clinical Biochemistry
18.0203	Clinical Biochemistry
18.0204	Clinical Pathology
18.0205	Physiology
26.0201	Biochemistry & Biophysics
26.0501	Microbiology
41.0101	Biological Laboratory Technology

(5)--Management Systems Technician

CIP#	Suggested Program Areas
06.0404	System Efficiency Analysis
06.1201	Management Information Systems
06.1302	Operations Research
07.0306	Business Systems Analysis
11.0301	Data Processing
11.0401	Information Sciences & Systems
11.0501	Systems Analysis
14.0901	Computer Engineering
15.0301	Computer Technology
15.0402	Computer Servicing Technology
21.0105	Graphic Arts
50.0801	Graphic Arts Technology

(6)--Waste and Environmental Systems Technician

CIP#	Suggested Program Areas
14.1401	Environmental Health Engineering
15.0502	Air Pollution Control Technology
15.0504	Sanitation Technology
15.0505	Solar Heating & Cooling Technology
15.0506	Water & Wastewater Technology

7. Industry Interviews

a. Eight industries were visited, and at each organization one or more senior management officials were interviewd. Although this provided a very minute sampling of Connecticut industry's high tech needs, the reources of this project precluded a more extensive survey. The firms visited included:

--The Naval Underwater Systems Center, New London, CT
--Analysis and Technology, Inc., North Stonington, CT
--A & T Technical Services, Inc., New London, CT
--Pfizer, Inc., Groton CT
--Data General Corporation, Woodstock, CT
--Pitney Bowes, Inc., Norwalk, CT
--Times Fiber Communication, Inc., Wallingford, CT
--United Technologies Research Center, East Hartford, CT

These firms varied from small to very large; from software through reasearch, development, and testing; and included manufacturing, production, and service function.

b. All indicated present and projected needs for technicians trained in high technology; their current supply was generally trained on-the-job, starting with public or private school associate degree graduates or technicians retired from the military service (a preferred source). In some cases a high school or voc-tech school graduate after on-the-job training or company sponsored continuing education courses worked up to a high tech job. One firm reached over into a neighboring state for technicians trained in optics and lasers. Although a few firms had established job descriptions in the high tech category, most were not a the entry level, since the incumbents were normally trained inhouse. In some cases, at least, if newly graduated high technicians with associates degrees were available, they would be considered for entry level positions.

c. All interviews emphasized the need for technicians well grounded in the fundamentals of math and science, together with the ability to communicate well, both written and orally. Several individuals expressed a need for technicians who could define and work out the prodecures for solving of basic computing technology would be required for all technicians in the near future.

8. Secondary-Vocational-Technical School Findings.

a. Relatively little information was discovered in the literature or in the contacts with industry that would indicate much potential in high tech jobs for graduates of secondary or voc-tech schools, unless additional on-the-job training or additional post-secondary education were acquired.

b. In the future, we can expect that for articulation to the college level, the K-12 student will need a much broader and more solid education, especially in mathematics, science and the oral and written communication skills. The increased curriculum requirements at the college level will leave little time for remedial work. Therefore, not only must K-12 curricula be upgraded, but the students' level of comprehension and skill must also be increased. Keyboard skill and basic computer literacy will be a requirement.

c. The ability to define problems and organize an approach to solving them is also perceived as a need.

B. Unanticipated Problems

1. A review of reports, studies, plans and surveys produced no detailed information regarding Connecticut's current high technology jobs or job projections. Information concerning types of high tech jobs, job descriptions, entry level skills, and present and projected numbers of jobs is generally unavailable.

Discussions with a limited number of industry representatives indicates that in some cases job descriptions and entry level skills were established; however, because of the emerging nature of many of the high tech jobs, job descriptions and skill requirements were evolving in many cases--with industry often not able to specify needs. At times industry is looking to the academic community for guidance. In some cases, industry begins with a "non-hi-tech" technician, and through an evolutionary on-the-job training program, develops a "high technician", together with the accompanying job description.

2. The lack of the baseline survey of high tech jobs and job projections leads directly to the second problem, namely, obtaining such a baseline. A survey of the scope needed to produce valid results would require substantial resources and time. A letter questionnaire would suffice only as an initial screening of the many thousands of Connecticut businesses and industries. Follow-up interviews of

top management would certainly be a requirement due to the evolutionary nature of hi-tech jobs, and because industry often does not know where or how the training of a "high technician" best is achieved.

In today's technological revolution, many times the interval between the development and the application of a new technology is so short that industry's managers find themselves unqualified to specify their needs, yet they must apply the new technology in order to stay competitive. It is then that the educational community can help industry, both in the application of the new technologies and in the development of required education and training programs for the workforce.

C. Conclusions

1. An adequately trained workforce is the most frequently stated incentive for attracting and retaining industry to and in an area. In the past, Connecticut has generally provided such a workforce. However, in view of the rapidly expanding needs of industry for "high technicians", and of the coordinated plans and programs in some other states, Connecticut is falling behind.

2. A comprehensive survey of industry's needs regarding a hi-tech trained workforce does not now exist. Such a survey would involve several thousand businesses at the least, and would require substantial resources in manpower and dollars. A proposed one year study. "Jobs for Connectinut's Future", scheduled to start in September of 1983, hopefully, will provide some of the needed job information.

3. Since other data related to industry are also involved, it would be more effective and efficient if a coordinated survey were planned and carried out, involving the governor's office, the legislature, the Departments of Education and Higher Education, the Labor Department, the Department of Economic Development, the Office of Policy and Management, and the Connecticut Academy of Science and Engineering.

4. A review of the planning documents of various state agencies shows a general need for coordination, and a need for focussing of resources on high priority problems, and on those with greatest payoff to the state.

5. In a high technology occupation survey, care must be taken to differentiate between high technology jobs and jobs within high technology industries. High technology jobs quite often do not yet have established job descriptions, and traditional job descriptions and entry level skills do not apply. Many of these jobs are still in an evolutionary state.

6. Industry is presently providing a substantial amount of high technology training of technicians on an in-house basis, at least partly because the requisite associate degree graduates are not available. Examples include computer technology, bio-engineering, laser and optical technology and office automation technology.

7. The technology areas that emerged from this study as having high potential for the Connecticut workforce are also among the lists developed by other investigators and in other areas. These areas are:

--Computing Technology
--Management Systems and Office Automation Technology
--Industrial, Manufacturing and Production Technology
--Communications, Information Transfer and Entertainment Technology
--Medical and Health Technology
--Bioengineering Technology

8. Due to the rapid evolution and development that occur in the high tech areas, constant vigilance is need for the timely identification of a rapidly emerging technology.

9. Preparation of secondary school students still leaves much to be desired. Significant remedial work in math, basic science and communication skills at the college level uses scarce resources and adds to the time spent in college. Problem definition and solving ability also needs strengthening.

10. At the post-secondary level, the emphasis will continue to be on a broad solid core curriculum in math and science, leaving little time in the two year associate degree program for more than one technology. The education of the "super-technician" or the "systems technician" must be accomplished via one or more options proposed in section VA4., i.e., a three year associate degree program; a work-study program of three and one-half years; options offered as a third year program granting a second associate degree; a 2 plus 2 program wherein the secondary schools at the 11th and 12th grade level initiate the curriculum that then is completed in two years at the post-secondary level; or a complete revision of one or more existing two year associate degree programs.

11. There is a growing need for programs at the technical colleges and at the vocational-technical school level for retraining or upgrading workers displaced by technological advances, and to provide opportunities for upgrading into higher level technical jobs. Fortunately, evening programs and continuing education programs are already in place at the colleges. There is a need to ensure that these

programs are reviewed frequently, and are revised to meet the needs of industry and the changing workforce.

12. The Technical Advisory Committees at the five technical colleges do not seem to be involved sufficiently in establishing requirements for, nor in the development of new or revised curricula or programs. Greater participation by Advisory Committee Members (and Regional Council Members) would have been helpful.

13. No high tech occupations were found with job descriptions and entry level requirements sufficiently developed. One program, Computer Systems Technology, was proposed for consideration by Thames Valley State Technical College.

14. Much of the findings and conclusions of this study also apply to the Community Colleges, Regional Universities, and to the University of Connecticut.

Recommendations

1. The State of Connecticut with leadership from the governor's office and support from the legislature, needs to develop a comprehensive master plan involving all facets of the state's governmental and administrative function; the goal for the plan is to make Connecticut a leader in this age of high technology. An important facet of this plan would pertain to education at all levels. The objectives of the plan should be realistic, and should be achievable in a reasonable time and with available resources.

2. The State Technical Colleges' Master Plan should provide goals and objectives to address the educational needs generated by the high and emerging technological needs of Connecticut's business and industry. The plan should address curricula, staffing, facilities and dollars. If possible, the plan should mesh in with the Department of Education Master Plan, which in turn should fit in with the Master Plan for the State of Connecticut.

3. A comprehensive survey of industry's present and projected needs regarding a workforce trained in high technology fields should be accomplished in the near future. Survey plans, instruments and analysis programs have already been developed (Ref. 19.). A survey coordinated with other state agencys' needs would be more effective--however, since this might involve considerable delay, a survey by the Department of Higher Education would be useful if accomplished soon. In addition, annual updates of such a survey should be scheduled.

4. Efforts should be made to involve more deeply the Technical Advisory Committees of the Technical Colleges in reviewing the needs for, and in the planning and development of new curricula. This should also apply to the retraining and continuing education needs as expressed in conclusion 11.

5. After a survey such as is recommended in 3 above is completed, then the five options addressed in conclusion 10 above should again be reviewed for possible action.

6. In order to provide a focal point and a pool of expertise in the technology areas identified as having a high potential for Connecticut's industry and workforce, a program should be initiated whereby each of the five State Technical Colleges is established as the center of expertise, or "high tech center" for one or more key high technology areas. Each "high tech center" would become the collecting and coordinating agent in its assigned technology area, e.g., Hartford State Technical College might be the high technology center Computing Technology. Each center would provide help to industry in the transfer of technological innovations, and would encourage industry to make known its needs. In addition, industry would be encouraged to participate in the development of programs and facilities.

High Technology Matrix - Page 1

Key Numbers	High Technology Areas and Applications	SIC Codes	Job Titles	Academic Subjects Technical Math 1	Calculus 2	Logical Analysis 3	Probability & Statistics 4	Computer Programming 5	Data Processing 6	Modeling & Simulation 7	Comptr Sys Microprocessors 8	CAD/CAM 9	Phys,Heat,Lgt,Mech,Snd 10	Modern Physics 11	Elec, Eltrncs, Magnetism 12	Semicond & Digital Tech 13	Communications 14	Control Systems 15	Applied/Fluid Mechanics 16	Heat Transf/Thermodyn 17	Mfg Engnrg Technology 18	Compos Matrl & Struct 19	Mfg & Prdctn Process 20	Energy Engnrg Technology 21	Biology/Biotechnology 22	Gntc/Bio Engnrg; Mcrobio 23	Marine Biology 24	Chemisty/Physical Chem 25	Organic Isotopic Chem 26	Clinical Chemistry 27	Marine Chemistry 28	Photncs,Lsrs,Fbr Optics 29	Nclr Phys/Ionizg Radtn 30	Physiology/Anatomy 31	Psychology 32	Medical/X-Ray Technology 33	E/M Tech, Radio, I/R, U/V 34	Fuel/Solar Cell Tech 35	MHD Tech, Supercond 36	Mgmt, Business Admn 37	Diagnostic Instruction 38
1	Bioengineering and Technology	26,28,283, 2834,286, 2861,9, 287,289	Bio Process Technician	●		●	●		●	●			●					●		●			●		●	●		●	●												●
			Bioscience Technician	●	●	●	●		●	●			●													●	●	●	●		●										●
			Genetic Engineering Technician	●		●	●		●	●			●													●		●	●												●
			Laboratory Technician	●		●	●		●	●		●	●					●		●						●		●	●												●
			Microbiology Technologist	●	●	●	●		●	●			●													●		●	●												●
			Science Technician	●	●	●	●		●	●		●	●	●	●	●		●	●	●								●	●			●									●
2	Building Management and Control Technology	17,343,356 36,364-6, 369,382, 3822,734, 89,891	Architectural Technician	●								●																													
			Electronic Technician	●	●	●	●		●	●		●	●		●	●	●	●										●													●
			Energy Technician	●		●	●		●	●			●											●																	●
			Energy Engineering Technician	●	●	●	●		●	●		●	●		●	●		●	●	●				●				●													●
			Industrial Engineering Technician	●	●	●	●		●	●		●	●		●	●		●		●				●				●													●
			Waste Technician	●																								●													●
3	Communications, Information Transfer and Entertainment Technology	365-7,369, 79,737	Electronic Technician	●	●	●	●		●	●		●	●		●	●	●	●										●													●
			Information Process Technician	●	●	●	●	●	●	●	●		●		●	●	●																								●
			Photonic Technologist	●	●	●	●		●	●			●	●	●	●												●				●									●
			Telecommunications Technician	●	●	●	●	●	●	●	●	●	●		●	●	●															●									●
4	Computing Technology	357,3573, 366,367, 369,737	Computer Programmer	●			●	●	●	●																															
			Computer Specialist	●		●	●	●	●	●	●	●	●		●	●																									
			Computer Systems Analyst	●	●	●	●	●	●	●	●	●	●		●	●																									●
			Data Processing Technician	●	●	●	●	●	●	●																															
5	Energy Management, Conversion, and Control Technology	28,29,35, 36,369	Bio Process Technician	●	●	●	●		●	●			●		●			●	●	●			●			●		●	●												●
			Electronic Technician	●	●	●	●		●	●		●	●		●	●		●										●											●		●
			Energy Technician	●	●	●	●		●	●		●	●					●	●	●				●				●											●		●
			Industrial Engineering Technician	●		●	●		●	●		●	●		●	●		●	●	●			●	●				●													●
			Nuclear Engineering Technician	●	●	●	●		●	●		●	●	●	●			●	●	●				●				●					●								●
6	Management Systems and Office Automation Technology	36,357,6, 60-7,70,73 737,80-3, 86,89	Computer Specialist	●		●	●	●	●	●	●	●	●		●	●	●																								
			Computer Systems Analyst	●	●	●	●	●	●	●	●	●	●		●	●	●																							●	●
			Information Processing Technician	●	●	●	●	●	●	●																															
			Telecommunications Technician	●	●	●	●		●	●	●	●	●		●	●	●																	●									●

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High Technology Matrix - Page 2

Academic Subjects

Key Numbers	High Technology Areas and Applications	SIC Codes	Job Titles	1 Technical Math	2 Calculus	3 Logical Analysis	4 Probability & Statistics	5 Computer Programming	6 Data Processing	7 Modeling & Simulation	8 Comptr Sys Microprossors	9 CAD/CAM	10 Phys,Heat,Lgt,Mech,Snd	11 Modern Physics	12 Elec, Eltrncs, Magnetism	13 Semicond & Digital Tech	14 Communications	15 Control Systems	16 Applied/Fluid Mechanics	17 Heat Transf/Thermodyn	18 Mfg Engnrg Technology	19 Compos Matrl & Struct	20 Mfg & Prdctn Process	21 Energy Engnrg Technology	22 Biology/Biotechnology	23 Gntc/Bio Engnrg: Mcrobio	24 Marine Biology	25 Chemisty/Physical Chem	26 Organic Isotopic Chem	27 Clinical Chemistry	28 Marine Chemistry	29 Photncs,Lsrs,Fbr Optics	30 Nclr Phys/Ionizg Radtn	31 Physiology/Anatomy	32 Psychology	33 Medical/X-Ray Technology	34 E/M Tech, Radio, I/R, U/V	35 Fuel/Solar Cell Tech	36 MHD Tech, Supercond	37 Mgmt, Business Admn	38 Diagnostic Instruction
7	Law Enforcement, Security, and Surveillance Technology	357,36, 369,366, 38,737	Computer Specialist	●		●	●	●	●	●	●		●		●	●	●																								●
			Information Processing Technician	●	●	●	●	●	●	●	●		●				●																								●
			Police Technologist	●		●	●		●	●			●				●											●						●	●					●	●
			Telecommunications Technician	●	●	●	●		●	●			●		●	●	●															●				●				●
8	Food Processing, Preservation, Packaging, and Marketing Technology	20,203, 355,73 89,Gov't	Bio Process Technician	●	●	●	●						●					●		●	●		●					●	●								●				●
			Chemical Technician	●	●	●	●						●							●			●					●	●												●
			Electronic Technician	●	●	●	●		●	●		●	●		●	●		●			●		●					●													●
			Industrial Engineering Technician	●	●	●	●		●	●		●	●		●	●		●	●	●	●		●					●					●			●				●
9	Industrial, Manufacturing, and Production Technology	10,20,22, 24,26-30, 32-38, 891	Electronic Engineering Technician	●	●	●	●		●	●		●	●		●	●		●			●		●					●									●				●
			Industrial Engineering Technician	●	●	●	●		●	●		●	●		●	●		●	●	●	●		●					●									●				●
			Manufacturing Engineering Technician	●		●	●			●		●	●		●			●	●	●	●		●					●									●				●
			Materials Technician	●		●	●		●	●		●	●							●	●	●	●					●													●
			Photonic Technologist	●	●	●	●		●	●			●	●	●	●				●	●		●					●				●					●				●
			Robot Technician	●	●	●	●		●	●		●	●		●	●	●	●	●		●		●																		
10	Material and Inventory Handling and Storage Technology	34-6,382, 3535	Computer Specialist	●		●	●		●	●	●		●		●	●	●	●					●																		
			Electronic/Mechanical Engnrg Techn	●	●	●	●		●	●		●	●		●	●		●					●					●													
			Industrial Engineering Technician	●	●	●	●		●	●		●	●		●	●		●					●																		
11	Medical, Physiological Psychological, and Health Technology	283,38, 381-6, 80	Clinical Laboratory Technician	●					●				●												●			●	●	●											●
			Cyto-Technologist	●	●	●	●		●				●												●	●		●	●	●				●							●
			Instrumentation Technician	●	●	●	●		●	●			●		●																						●				●
			Medical Technologist	●					●				●												●			●	●	●			●	●		●	●				●
			Prosthetic Technician	●	●	●			●	●					●			●				●												●							
			Radiology Technician	●	●	●			●				●	●	●										●			●					●	●		●					●
			Surgical Technologist	●									●												●			●	●	●				●							●
			Therapy Technician																						●			●						●	●		●				●
12	Insect, Pest, and Disease Control	287,289, 334,369, 382	Biotechnologist	●	●	●	●		●	●			●		●										●	●		●					●				●				●
			Chemical Technologist	●	●	●	●		●	●			●		●													●	●												●
			Electroacoustic Technician	●	●	●	●		●			●	●		●	●	●											●													●
			Electronic Technician	●	●	●	●		●	●		●	●		●	●	●											●									●				●
13	Waste and Pollution Management Technology	147,28, 355,359, 49,89	Biological Technician	●	●	●	●		●	●			●												●	●		●	●								●				●
			Energy Technician	●	●	●	●		●	●		●	●		●			●		●	●		●	●				●													●
			Hazardous Waste Technician	●		●	●						●					●										●	●												●
			Industrial Engineering Technician	●		●	●		●	●		●	●		●			●	●	●	●		●	●				●													●
			Waste Technician	●																								●													●
14	Military Research, Development, Test, and Evaluation		Computer Science Technician	●	●	●	●	●	●	●	●	●	●		●	●	●	●																							●
			Electronic Technician	●	●	●	●		●	●		●	●		●	●	●	●										●										●	●		●
			Instrumentation Technician	●	●	●	●		●	●		●	●		●	●	●	●																				●	●		●
			Mechanical Technician	●	●	●	●		●	●		●	●		●			●	●	●								●													●
			Physical Science Technician	●	●	●	●		●	●		●	●		●	●	●	●	●	●							●	●	●		●							●	●		●

HIGH TECHNOLOGY JOB SURVEY
STATE TECHNICAL COLLEGES - TECHNICAL ADVISORY COMMITTEE MEMBERS
PERCENT OF RESPONDENTS BELIEVING JOB POTENTIAL HIGH

JOB TITLE	1 10 20 30 40 50
Computer System Technician	*** 48
Biomedical, Biochemical, Bioengineering	************************************* 37
Industrial/Mfg Production/QA/QC Engineering	*********************************** 33
Electromechan Robotics Automation Tech	*************************** 26
Database Mgt Systems Tech	***************** 15
Management/ Management Info Systems Tech	***************** 15
Waste/Environ Systems Tech	***************** 15
Communication Systems Tech	************* 10
Electro-Optical Tech	************* 10

TOTAL RESPONDENTS - 27

COMPUTER SYSTEMS TECHNOLOGY

CURRICULUM

(Two-Year Sequence)

C = Class Hours L = Laboratory Hours Q = Quarter Hours Credit

FIRST YEAR

First Quarter	C	L	Q
AS110 Intro to Lit	4	0	4
MA110 Tech Math I	4	0	4
*PH111 Physics (Mech)	3	2	4
*ET111 Electricity I	4	2	5
DP115 Intro to Prog	3	3	4
Totals..................	18	7	21

Second Quarter	C	L	Q
AS120 Basic Comm	4	0	4
MA120 Tech Math II	4	0	4
*PH121 Physics (HSL)	3	2	4
DP123 Software Design	3	0	3
*ET121 Electricity II	4	2	5
Totals..................	18	4	20

Third Quarter	C	L	Q
AS130 Tech Comm	4	0	4
MA130 Calculus I	4	0	4
*ET135 Intro to Electr	3	2	4
DP135 Data Base Systems Design	3	0	3
ET223 Projects I	1	4	3
Totals..................	15	6	18

SECOND YEAR

Fourth Quarter	C	L	Q
AS212 Economics	3	0	3
DP227 RPG Prog	2	2	3
MA210 Calculus II	4	0	4
*ET212 Electronics I	3	3	4
DP136 FORTRAN I	3	3	4
Totals..................	15	8	18

Fifth Quarter	C	L	Q
AS221 Psych & Hum Rel	4	0	4
MA213 Statistics	3	0	3
*ET222 Electronics II	3	3	4
*ET224 Digital Ckts I	3	3	4
*ET234 Elec Ckts & Appl	3	3	4
Totals..................	16	9	19

Sixth Quarter	C	L	Q
AS232 Sociology	3	0	3
*ET236 Digital Ckts II	3	3	4
DP237 Assembler Prog	3	3	4
*DP242 Microcomputers	2	2	3
* Applications & Systems	2	2	3
Totals..................	13	10	17

TOTAL CURRICULUM

Quarter Credits - 113

Contact Hours - 139

* New Science & Electrical courses added to present DP curriculum.

APPENDIX I

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NEEDS ASSESMENT ANALYSIS
AND COMPUTER ACQUISITION STUDY
FOR SFCC

Prepared for
The Spokane Falls Community College
High Technology Committee

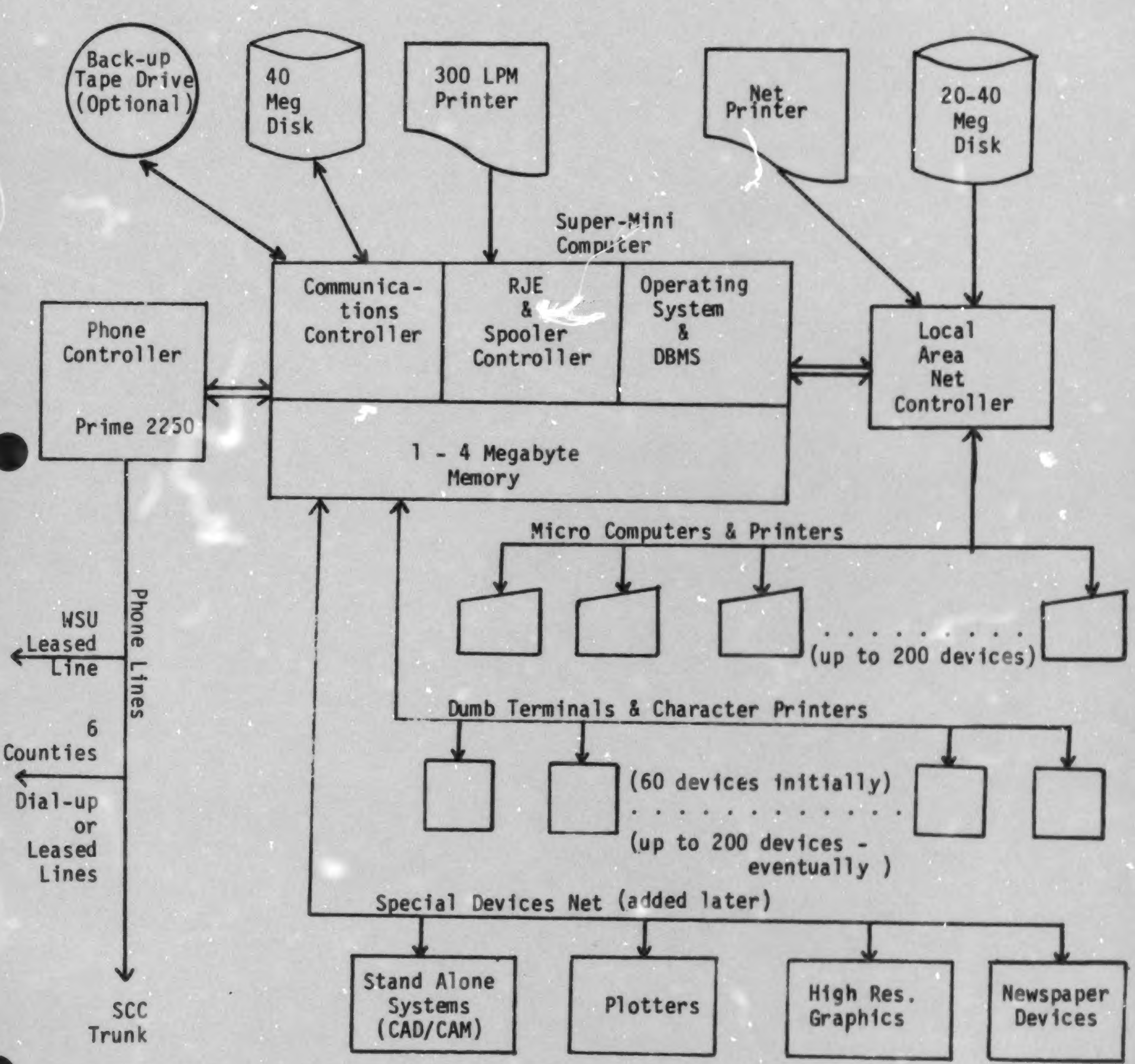
by D. E. Willingham

April 1983

ABSTRACT

An analysis of the computing needs for SFCC and Extension Services for the next five years is presented and a proposed system is proffered. The proposed system is one that is capable of expanding as the Disrict develops integrated communications and educational services to the six county district area. The system utilizes micro computers, a mini computer, and the Washington State University Amdahl mainframe system. Particular care is taken to apply each type of computer in those areas for which each is best suited. The cost for such a system is estimated as $1.3 million over the next five years.

Proposed System


Back-up Tape Drive (Optional)
40 Meg Disk
300 LPM Printer
Net Printer
20-40 Meg Disk
Super-Mini Computer
Communica-tions Controller
RJE & Spooler Controller
Operating System & DBMS
Phone Controller
Prime 2250
Local Area Net Controller
1 - 4 Megabyte Memory
Micro Computers & Printers
. . . . (up to 200 devices)
Dumb Terminals & Character Printers
(60 devices initially)
. . . .
(up to 200 devices - eventually)
Special Devices Net (added later)
Stand Alone Systems (CAD/CAM)
Plotters
High Res. Graphics
Newspaper Devices
Phone Lines
WSU Leased Line
6 Counties
Dial-up or Leased Lines
SCC Trunk

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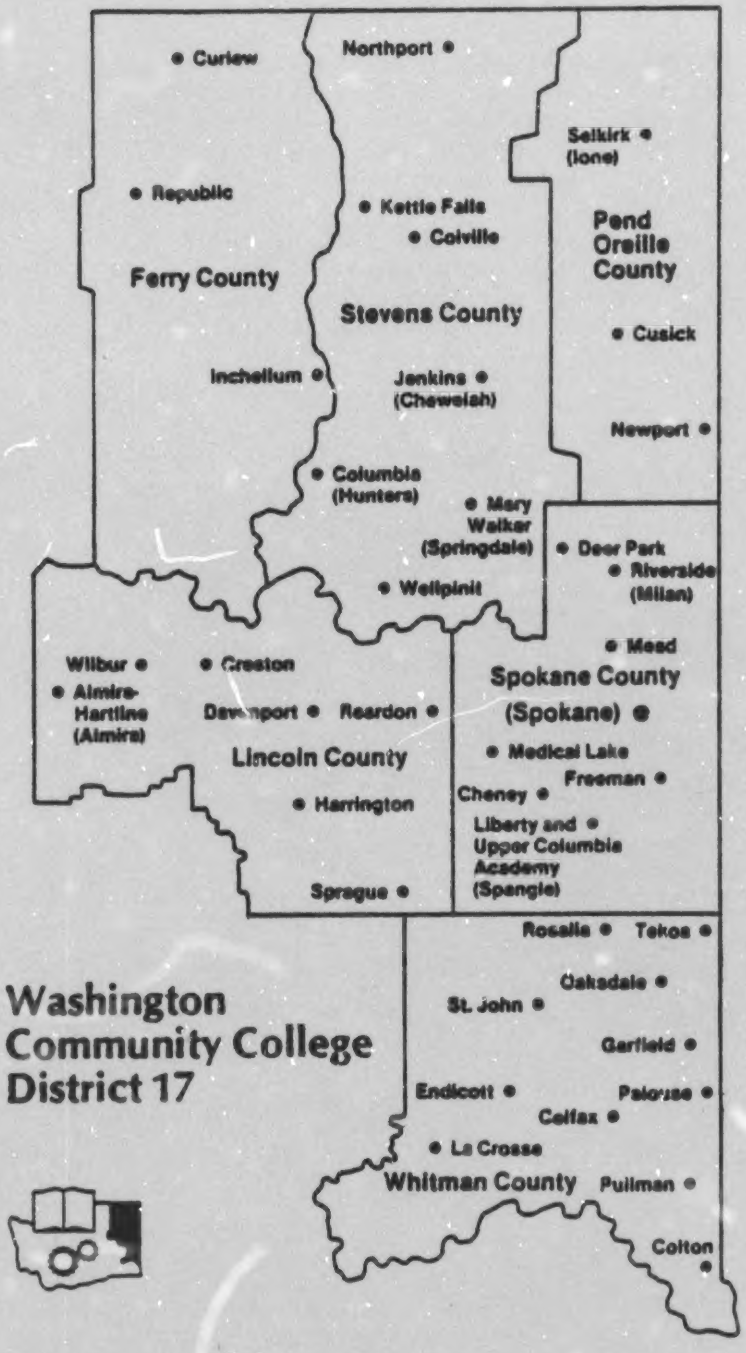
1.0 Introduction

This study analyzes and projects the academic computing needs for SFCC for the next five years. Requirements are developed for a computing system that serves these needs and provides for flexible adjustment to unanticipated developments.

Because of the importance of serving the entire district and because of the alignment of the third unit with SFCC, the computing needs incurred in serving our six county extended area have also been included. It is assumed that Spokane Community College is developing a similar statement of needs which can be incorporated with this analysis at the district level.

Clear administrative needs have been omitted. In cases where it is not clear if a particular need is administrative or academic, the need has been identified and included. The overriding criteria of this study is to identify needs rather than to be overly concerned with an appropriate division of responsibility.

FIGURE 2-1


Curlew
Northport
Selkirk (Ione)
Republic
Kettle Falls
Colville
Pend Oreille County
Ferry County
Stevens County
Cusick
Inchelium
Jenkins (Chewelah)
Newport
Columbia (Hunters)
Mary Walker (Springdale)
Deer Park
Riverside (Milan)
Wellpinit
Mead
Wilbur
Creston
Almira-Hartline (Almira)
Spokane County
(Spokane)
Davenport
Reardon
Lincoln County
Medical Lake
Freeman
Cheney
Harrington
Liberty and Upper Columbia Academy (Spangle)
Sprague
Rosalia
Tekoa
Oakesdale
St. John
Washington Community College District 17
Garfield
Endicott
Palouse
Colfax
La Crosse
Whitman County
Pullman
Colton

2.0 Assessment of Needs

In assessing our future, it is necessary to understand the geographic area that is being considered, trends and task forces that are now working within the state and trends within the campus and extension services. Upon gaining this perspective, projections can be made that will eliminate the myopic view that can sometimes take place when dealing with collegial problems. An open view will enable us to make wiser uses of available resources.

2.1 Perspective

Computing needs in the past have tended to emphasize campus computer class enrollments and time requirements. This view is no longer applicable. There is growing evidence that the role of the community college computing and information system will move more and more to the efficient disbursement of information from data banks and data centers to outlying educational centers. While this change may not affect the normal campus classroom delivery of education, it will have a major impact upon the computer delivery systems of the future.

Already within the state of Washington there are major endeavors taking place. Through these endeavors it is evident that a partnership in information delivery is beginning to develop between the community colleges and the four year institutions.

WSU has received a state mandate to research and create a telecommunications network capability that can be drawn upon by the state. There is a consortium entitled the Partnership for Rural Improvement (PRI) that has a membership composed of WSU, Wenatchee Vally College, Evergreen, Clark Community College, Big Bend Community College and District 17. The PRI views the role of WSU as a major information center that will disperse information through the community colleges to outlying communities. Elements within WSU view the role of the community college as the FIRST POINT OF ENTRY for information dispersal.

A task force operating through EWU is looking at local governments' computer needs. The need for a government computer clearing house similar in function to, and if possible operating in conjunction with, the Community College Computer Consortium is being discussed. This suggests the possibility of some tie-in between local governments and college campusses in a computer network.

The Energy Extension Services Agency is an agency charged with coordinating energy intensive developments within the state. They have certain information delivery needs that will enable outlying areas to perform energy conservation strategy analyses.

Community College District 17 is the largest geographical district in Washington and one of the largest nationally. Our six county area is shown in Figure 2-1. Any computer system that is developed at this district should take into account the responsibility of information delivery to the entire district. A major change has taken place in communications in the last few years so that both data transmission and voice transmission can be, and are, computer controlled.

Thus the entire district can be tied together via telecommunications. Our District is just now installing a modern computer controlled communication net capable of transmitting data at high speeds. Soon a new capability will be available that will dramatically affect the way the district discharges its educational responsibility to the outlying communities. A major study is now underway that is a joint venture of extension services and WSU through the PRI. This study will investigate the development of satellite information/educational centers throughout our district. The information centers are intended as pilot/models for the entire state of Washington. Properly implemented these centers could be major information dispersal sites that serve local governments, and provide energy analysis, agricultural data networking and many other functions. Properly designed, our computer network can be the First Point of Entry for these centers. The Network could then route information and computing requests to appropriate data banks (national or local) and computer systems (local, WSU, or national).

All of this is possible and available with today's technology. It is our task to ensure that it is accomplished efficiently by developing a flexible system that keeps in mind the role that each level of the higher education (and their computers) performs best. It is amidst this larger context of a network that links SFCC, SCC, the six county rural area, EWU and WSU, that this discussion of District 17 computer needs takes place.

2.2 Analysis of Trends

2.2.1 SFCC Campus

Computing courses on campus are in tremendous demand, as one would expect in a new technology that is advertised as the "be all" and "end all" of future employment. There are, however, other significant long-term trends developing.

The primary role of the future computer system will be as an aid and tool in disciplines that are not directly computer related. That role is just now being appreciated by the faculty. This academic year there has been one symposium by non-data processing faculty about how they use the computer as an aid. In a seminar by the Display Design Department, a guest lecturer demonstrated computer aided drafting and design capabilities. The Music Department is using a micro computer graphics program to enhance music theory presentations.

A major vocational thrust this past year has been to develop computer user classes that can be incorporated into existing vocational programs. One instructor has been hired for this development and industry has been involved in specifying competencies needed by vocational graduates.

In March a Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) symposium was given through joint sponsorship of District 17 (SFCC) and Gonzaga. The conference was held at Gonzaga and was limited to local industry groups. Each company was restricted in its attendance but there were still 200 attendies. It was felt by a number of representatives at this meeting that the community college had a significant future role to play in training CAD/CAM operators and in training general users.

Thus, the future campus computer system's role will be to provide test preparation and lecture augmentation, extensive student and faculty word processing, data banks for chemistry, accounting, and economics (to name a few), and graphics and CAD/CAM as well as serving as a tool for teaching computer languages and computer literacy.

2.2.2 Six Counties

The larger considerations of the extended district have been discussed in section 2.1. These considerations may seem to be somewhat futurist oriented and, perhaps, would seem to need a large scale educational thrust to motivate and enable full usage of such an integrated delivery system.

However, certain trends are already evident. There are almost 1000 people this year taking non-credit introductory computer literacy and computer programming courses from Extension Services. There is increasing demand for courses that will detail how to select and use micro computers on the farm, in small businesses, and in households. There is demand for how to select and use computer applications programs. Even given these demands, the primary area now being served is local to Spokane and there is a growing realization that this is just the tip of the iceberg within the six counties.

High schools are using micro computers for their students, but in general they have too few micros and instructors are not always well prepared. Partnerships between the high schools and the extension services do exist for cooperative equipment usage, but both educational units operate with minimal equipment budgets. A closer working relationship would result in improved computer classes as high school instructors were exposed to better computing practices and equipment would be used more extensively. Such cooperation might initially take the form of shared stand alone micro computers but could eventually include shared communications lines and less expensive dumb terminals tied to the college's system.

2.3 Projected Computing Needs

This section details the various functions that a new computer system must serve within the campus and extension services. These functions are then detailed by campus department and extension division in tables. The tables provide estimates of numbers of students, computing hours, type of computer systems, and numbers of delivery devices that are appropriate for the various functions.

2.3.1 SFCC Campus

The functions of the computer in academic computing can be divided into those that:

1. aid the instructor in performing his instruction and testing;
2. provide course augmentation in which the computer becomes an aid to learning;
3. enable the programming of the computer for those classes in which learning computer manipulation is an integral part of the course;
4. provide specialized capabilities such as CAD/CAM, Visual Art Graphics, and journalism/newpaper;

2.3.1.1 Functions That Aid the Instructor

Among the functions the computer provides the instructor are:

a) test preparation through maintenance of test banks that can be accessed randomly;
b) test analysis-item analysis;
c) records maintenance-Electronic Gradebook;
d) records analysis;
e) electronic mail;
f) lecture demonstrations;
   graphics,
   function analysis,
   color display.

Most of the functions above can be accomplished with conventional low resolution dumb terminals or micros. Physical placement of these devices will be discussed in Section 3.1. In certain cases, lecture demonstrations may require specialized terminals (high resolution graphics terminals, micro computer devices, color monitors, etc.). Such devices will be essential if the new system is to be a true aid in demonstrating complex concepts.

2.3.1.2 Course Augmentation Functions

Perhaps the principal augmentation function for academic courses will be the computer's word processing capability. Used appropriately, this function can aid students in preparing general and technical reports and themes. In particular, the student can be free to concentrate on material content and structure. The instructor will be free to require changes that improve content knowing that he is not forcing extensive repreparation for minor changes. Even major changes become less cumbersome to everyone involved. While this aid does provide a freeing aspect, it makes it incumbent upon the student to learn some typing and word processing skills (at least on the computer system). The college must make it possible to obtain these skills easily, quickly and without penalty for minimal performance.

Skill drills must be available for mathematics, language courses, and others. Data banks are necessary for accounting problems, drills, and computerized accounting, economics, and simulations. Data banks must be available for some technical courses such as chemistry and astronomy. Graphics packages will be necessary for the student to graph mathematical and business functions, for chart preparations and for integration of figures into word processing text.

2.3.1.3 Computer Intensive Courses

Historically, serving the computer intensive course needs has been the primary function of whatever computer delivery system we have had. This function must still be maintained but for more students, more efficiently and more economically. New languages must be available to the student as they become important in the field. At present, language courses in BASIC, FORTRAN, COBOL, PASCAL, and ASSEMBLER are offered.

2.3.1.4 Specialized Capabilities

Graphics needs in several technical fields will require specialized equipment. High resolution color graphics will be necessary in displaying certain materials, particularly in course areas of mathematics, physics, engineering and CAD/CAM. Specialized plotters and data entry tablets will be necessary for architecture as well as CAD/CAM. Newspaper systems (for journalism) are of a specialized nature especially with regard to text editing software and galley production.

Equipment compatibility is always a particularly important aspect of these specialized areas. For example, CAD/CAM work stations have been very expensive and have tended to be dedicated devices. More and more it has been found that all devices must be able to communicate with each other and that software specifications are extremely important.

These specialized items will not be developed initially in all areas. They may require specially funded development projects, but they must be anticipated in the overall system design.

2.3.2 Extension Division

As has been indicated, the extended role of the district could eventually become the most demanding for our information system. Initially, however, this role will not take the extensive form to which it will evolve.

Presently a few non-credit courses in computer literacy and BASIC programming are offered by the extension. Assignment of sufficient sets of micro computers to the extension could be made with the intent that units would be transferred to instructional sites. Alternately, micros could be purchased in joint cooperation with high schools so that more complete utilization of equipment could be made.

As the extension role expands to include additional non micro based languages as well as greater information transmission for decision making, the equipment may need to change in its method of usage. This change would reflect the greater dependance upon telephone hook-up to the college's computer system and would be in the form of micro computers that could act as intelligent terminals. Although these are different functions, the micro computers are the same devices as before.

2.3.3 Delivery System Units

2.3.3.1 SFCC Campus

Tables 2.3.3-1 through 2.3.3-4 provide an estimate of the computing needs for SFCC. Table 2.3.3-1 details the instructional overhead necessary for future instruction which will take advantage of the computer. It is important that the computing systems include terminals for private office use. The table reflects a modest number of faculty terminals initially, but the assumption is made that within five years one of every three instructors will have a terminal.

Also indicated in the table are high resolution graphics/color monitors that will be necessary to present visually accurate graphics to classrooms.

Table 2.3.3-2 shows an estimate of student computing demand over the next five years in those areas that are not computer intensive. This is the major service function that the system must provide in the future.

Table 2.3.3-3 looks at those classes that use the computer extensively. The estimates in this table are perhaps the most accurate since they are based upon courses for which data has been collected over several quarters. As can be seen, in the near term the number of devices required to serve this function are the greatest of all the functions.

All three tables attempt to align functional tasks with the appropriate computer system.

Not addressed by these tables are the future specialty needs of CAD/CAM, pre-architecture graphics, and journalism. It will be expensive to obtain appropriate devices for these disciplines--perhaps as much as $100K to $500K for each. Any system considered will have to be able to work with such future devices, but their costing will not be considered in this study.

Table.2.3.3 summarizes the memory and device items detailed in the above tables. This table shows a projected need of nearly 280 terminals, micro computers, and word processors by 1988. It is, of course, difficult to state exactly the functions that each device will fullfil. The assumption has been made that micro computers should be used for most of the introductory DP classes and for BASIC introduction. Most text editing and WSU mainframe entry functions have been assumed to be performed on a mini computer system. Word processors have been included primarily for those situations in which very specialized word processing skills are necessary that, to date, do not seem adequately served by super mini systems. The mix of devices can be changed and probably will be within the first five years of system operations. However, the total number of devices should be considered as realistic.

In one to two years, the student devices shown in the tables will provide for one hour of computer time per week per student assuming each device is available 50 hours per week and is used at 80% capacity (3600 students assumed). In five years, the devices shown will provide for two hours per week again assuming 50 hours per week availability, 80% usage, and 3600 students.

TABLE 2.3.3-1
SPOANE FALLS COMMUNITY COLLEGE CAMPUS
Instructional Overhead Requirements

FUNCTION	MEMORY ALLOCATION M - Megabytes K - Kilobytes						I/O Devices & Usage Time					
	MICRO AREA NET		MINI-COMPUTER		MAINFRAME		MICRO COMPUTERS		TERMINALS & PRINTER		MAINFRAME	
	1-2 yr	5 yr	1-2 yr	5 yr	1-2 yr	5 yr	1-2 yr	5 yr	1-2 yr	5 yr	1-2 yr	5 yr
Test preparation and data banks	1.0M	3.6M	600K	2.4M								
Student class room records maintance (elect. grade book)	60K	240K	40K	160K								
Records analysis	10K	40K	10K	40K								
Word processing	200K	500K	200K	1M								
Research and misc.	200K	500K	200K	1M	500K	4M	5	10	4P 12T	10P 40T	5hrs	60hrs
Lecture Aids Graphics and function analysis color displays	100K	250K	100K	250K			5* in classroom	20* in classroom	10T* in classroom	30T* in classroom		
Totals	1.6M	5.1M	1.1M	4.8M	.5M	4.0M	10MC	30MC	[illegible]2T [illegible]P	70T 10P	5hrs	60hrs

* - High resolution color monitors with terminals

P - Printer
T - Dumb Terminal
MC- Micro computer

TOTAL DEVICES	1-2 yrs	5 yrs
	10MC	30MC
	22T	70T
	4P	10P

Note: Memory allocation is based on total bytes per year.
For records, it is assumed that masters will be made at the end of a year.

Assumptions:

1-2 yrs	5 yrs
a) 1 class in 20 will use computer aided testing	a) 1 class in 5 will use computer aided testing
b) 1 class in 40 will use records analysis	b) 1 class in 10 will use records analysis
c) 1 class in 10 will use word processing and electronic mail	c) Most instructors will use word processing and electronic mail
d) 1 class in 20 will use lecture aids	d) 1 class in 5 will use lecture aids
e) 1 instructors in 40 will do research or misc.	e) 1 instructor in 10 will do research or misc.
f) 1 dumb terminal per 10 instructors	f) 1 dumb terminal or micro per 3 instructors

TABLE 2.3.3-2

SPOKANE FALLS COMMUNITY COLLEGE STUDENT USAGE PER QTR

--NON COMPUTER INTENSIVE COURSES --

Dept./Course/Function WP - Word Processing CP - Canned Programs O - Other	Students per QTR		Term/Micro HRS/QTR/STD		Memory Allocations M - Megabyte K - Kilobytes				USAGE TIME HOURS				Terminals/Micros Required	
					Micro Computer Local Area Net		Mini computer		Micro Computer Local Area Net		Mini computer			
	1-2 Yrs	5 Yrs	1-2 Yrs	5 Yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 Yrs	5 Yrs
Campus														
Student reports (WP)	100	600	2	4	.1M	1.0M	.5M	2.0M		1 K	.2K	1.4K		2MC 3T 1
Communications														
Eng Comp. Lab (WP)	200	600	3	5			1.0M	3.0M			.6K	3.0K		
Lang Drill (CP)	60	200	1	3			.1M	.3M			1.0K	5.0K		
Testing & Misc (O)	200	1000	5	5			.1M	.5M			1.0K	5.0K	4T 2P	17T 5P
Science														
Chem Labs (CP)	200	250	4	6					.8 K	1.5K			2MC 1P	4MC 1P
Physics Labs (CP)	50	150	2	3					.1 K	.45K			2MC 1P	4MC 1P
Life Science (CP)	50	150	1	3					.05K	.45K			2MC 1P	4MC 1P
Astronomy (CP)	30	40	1	2					.03K	.08K				
Math Lab - Drill (CP)	100	300	1	3					.1	.9 K			2MC 1P	4MC 1P
Testing & Misc	100	500	3	4	.1M	.5M			.3 K	2.0 K				
Business														
Simulation Drill (CP) (Econ, Acctg, Mid Mgt, Per Fin, Real Estate)	300	800	.5	2	.1M	.2M			.1K	1.0 K	.05K	.6K		2MC 2T
Secretarial (CP) (WP classes included in Table 2.3.3-3)	150	200	5	10							.75K	2.0K	2T 1P	4T 1P
Testing and Misc	100	800	3	5			.1M	.5M			.6K	4.0K	1T 1P	3T 3P
Human Services														
Testing and Misc (O)	50	200	1	4			.05M	.2M			.05K	.8K	1T 1P	2T 1P
Social Sciences														
Testing and Misc (O)	50	200	1	4			.05M	.2M			.05K	.8K	1T 1P	2T 1P
Art & Creative Art														
Music Theory (CP)	30	100	2	4	.1M	.2M			.06K	.4K			1MC	3MC
Pre-arch & DD (see special equip)														
Testing and Misc (O)		100		3	.1M	.2M						.3K		1T
TOTALS					.5M	2.1M	1.9M	6.7M	1.5K	7.8K	3.3K	18.5K	9 MC 9 T 10 P	23 MC 39 T 16 P

TABLE 2.3.3-3

SPOKANE FALLS COMMUNITY COLLEGE STUDENT USAGE PER QTR

-- COMPUTER INTENSIVE COURSES --

Dept./Course/Function WP - Word Processing CP - Canned Programs O - Other	Student/QTR		Term/Micro HRS/QTR/STD		Memory Allocations M - Megabyte K - Kilobyte				USAGE TIME HOURS				Mainframe Job Submission		Terminals/Micros Required	
					Micro Computer Local Area Net		Mini computer		Micro Computer Local Area Net		Mini computer					
	1-2 Yrs	5 Yrs	1-2 Yrs	5 Yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 yrs	5 yrs	1-2 Yrs	5 Yrs
DPCS (O)																
Computer language																
Basic beg/adv/disc	130	200	30	30	5.0M	8.0M			3.9K	6.0K						
Fortran beg/adv	50	60	30	30	2.5M	3.0M	1.5M	1.8M	1.0K	1.2K	.5K	.6K	1.0K	1.2K		
Pascal beg/adv	40	60	30	30	1.7M	3.0M	1.5M	1.8M	.8K	1.0K	.4K	.8K	.8K	1.2K		
Cobol beg/adv	50	60	40	40	2.5M	3.0M	1.5M	1.8M	1.2K	1.4K	.8K	1.0K	1.0K	1.2K		
Assembler beg/adv	30	40	30	30			1.8M	2.4M			.9K	1.2K				
Micro Program	50	60	40	40	.5M	.6M	.5M	.6M	1.0K	1.2K	1.0K	1.2K				29MC 11T
Intro Courses	150	200	2	3	.3M	.4M			3.0K	6.0K					18MC 6T 6P	10P
GBUS (CP)																
Desk Top Computer	400	600	15	15	10.0K	15.0K			6.0K	9.0K						
Elect Spread Sheet	250	500	15	15	10.0K	20.0K			3.8K	7.5K						
Bus Graphics	200	300	15	15	10.0K	10.0K		10.0K	3.0K	2.5K		2.0K				
Applied bus data base	150	300	30	30	.1M	.1M		.1M	4.5K	6.0K		3.0K				47MC 9T
Computer Actg	60	120	30	30	.1M	.1M		.1M	1.8K	3.0K		.6K			32MC 8P	13P
SECRETARIAL (WP)																
Secr WP beg/adv and secr elec. mail	60	120	60	60			50.0K	100 K	3.6	7.2K					6WP	12WP
System Instr. In WP	400	1500	10	10							4.0K	15.0K			7T 1P	25T 6P
TOTAL					12.7M	18.0M	6.8M	8.6M	30.0K	45.8K	7.6K	25.4K	2.8K	3.6K		

TOTAL DEVICES	1-2 Yrs	5 Yrs
MC - Micro Computers	50MC	76MC
T - Dumb Terminals	13T	44T
WP - Word Processors	6WP	12WP
P - Printers (character)	15P	29P

TABLE 2.3.3-4

SUMMARY OF REQUIRED DEVICES
FOR SFCC COMPUTING

	MICRO NET		MINI COMPUTER		CHARACTER PRINTERS
1-2 Years	memory	micro computer	memory	terminals	
Instructional	1.6 mega bytes	10 MC	1.1 mega bytes	22 T	4 P
Student Non-computer classes	.4 mega bytes	9 MC	2.1 mega bytes	9 T	10 P
Computer Intensive classes	12.7 mega bytes	50 MC 6 WP	6.8 mega bytes	13 T	15 P
TOTAL	14.7 mega bytes	69 MC 6 WP	9.8 mega bytes	44 T	29 P

5 years

Instructional	5.1 mega bytes	30 MC	4.8 mega bytes	70 T	10 P
Student Non-comp classes	2.1 mega bytes	23 MC	6.7 mega bytes	39 T	16 P
Computer Intensive classes	18.0 mega bytes	76 MC 12 WP	8.6 mega bytes	44 T	29 P
TOTAL	25.2 mega bytes	129 MC 12 WP	19.1 mega bytes	153 T	55 P

P--Printer
T--Terminals
MC--Micro Computers
WP--Word Processors

Note: a megabyte is one milion characters

2.3.3.2 Extension Services

No table has been prepared for extension services. It is apparant that their needs will continue to grow. For now these needs must be satisfied by stand alone micro computers. A good beginning estimate would be a need for 40 micros. It is not unreasonable to expect that an additional 10 to 20 micro computers will be needed each year.

At the time that educational centers are developed in the six counties, dial-up or leased line tie-in to the computer system will be necessary. This should present no major difficulty if planned for appropriately. We should, therefore, expect multiple port entry via the telecommunications system from several sites. The micro computers purchased in the meantime can then serve as intelligent terminals for the system. Each community site should probably be expected to require about 10 micro computers.

3.0 Computing Environment

The computing environment includes the physical placement and the logical characteristics of computing devices. Emphasis is given to location and use of input and output devices. The placement of the main computer system is not addressed, since there seems to be no place at SFCC, at present, to locate it. Wherever it is located, however, should be central and must provide an appropriate environment for the machine.

3.1 Physical Placement

With regard to the campus, it is expected that input/output devices and micro computers will be placed at several sites.

There is presently a business micro computer lab. It is expected that location of several micro computers would continue to be maintained in the Business Department. Several microcomputers would be placed, one per classroom for instructional purposes, throughout the campus particularly in those classrooms needing calculations and graphical systems display. In particular one would anticipate this need in mathematics, science, and data processing classrooms. Several micro computers would need to be placed in the micro computer programming lab, chemistry lab, physics lab, and music department. All micro computers are intended to be part of a campus local area net system.

Dumb terminals, primarily for word processing and text preparation would be placed in the communications lab, secretarial sciences lab, library, business lab, micro computer lab, and other sites. Text preparation is intended to include preparation of high level language programs for subsequent transfer to WSU.

Because of the nature of the services provided for faculty, terminals must be placed in areas accessable to faculty in essentially an exclusive and private environment. This is generally accomplished by installing terminals in instructors' offices. While it is probably not necessary for every instructor's office to have a terminal, the five year plan should have as a goal to provide a terminal for each office in which the instructors indicate a desire for and demonstrate a knowledge of terminal usage.

With regard to hard copy, it is anticipated that there will be one primary line printer located at the mini computer site with all other printers being existing character printers or additionally purchased (inexpensive) low speed devices. This, of course, excludes CAD/CAM and specialty devices which will be placed at the physical area for which they are purchased.

Extention services will require portable micro computers or intelligent terminals (eventually with modems). Such an approach will maintain maximum flexibilty.

3.2 Security

It is a requirement that every computing component be secured. Classroom units must be either secured portable units or contained in lock down permanent positions. Laboratory environments must be supervised and the computers locked down. Instructor devices must be locked down in their offices. Theft insurance may also be required.

3.3 Logical Environment

Several functions for the computer system have been identified and several types of units have been discussed.

A pervading philosophy is intended for the system under consideration. That philosophy is that micro computers should be used for those purposes for which micros are suited, mini computers should be used for those purposes for which they are suited, and mainframe systems must be used for the large tasks and data bases for which they are best suited.

The tables in Section 2.3 categorized functional tasks in terms of these types of suitability. Thus there is a need to do much of the computer literacy and perhaps most of the BASIC on the micro computers. High level languages such as COBOL and FORTRAN should utilize the WSU mainframe, but that system should not be used for the composition of these programs. Word processing tasks can be performed both at the micro level and with dumb terminals hooked to the mini system.

Thus, different tasks will be performed on different parts of the system. But this should and must be mostly invisible to the user. In using a dumb terminal for development of text (whether for testing, language composition, or general word processing) the same word processing system should be in use. The micro computers should be in a local area net that can work with the mini computer. The same word processor (used in the mini system) should be down loaded automatically to the micro computer local area net. Whether the micro is working directly with the mini as a dumb terminal or whether it is working as a temporary stand alone computer, the micro must operate essentially the same. The choice of which mode of work should be easily selected by the user. It is assumed that the micros will down load BASIC programs from a hard disk maintained by the local area net and then operate as stand alone computers in executing the programs.

High level computer languages will be composed locally, spooled and communicated directly to the WSU Amdahl computer over a leased line. Results will be communicated back, spooled and delivered to the user at any terminal from which he makes the request (or at the main printer).

The capability must exist for multiple dial-up and leased line channels to the six counties. Micro computers should be able to work over these channels in much the same way that the local area net of micros functions with the mini system.

Eventual use of CAD/CAM and specialty terminals should enable down loading of tasks where appropriate and the development of data files on the mini system. Thus some work could be developed on the mini system and then transferred to the CAD/CAM system for further processing.

4.0 Present Computer Environment at SFCC

The following sections detail the present computing environment at SFCC including courses, department structure, and equipment.

4.1 Courses

Presently, courses that utilize the computer fall roughly into two categories--those that teach how to use the computer as a tool and those that teach programming.

Courses specific to the computer science department are titled DPCS, however, there are a few one credit general usage computer intensive courses taught in the General Business curriculum. The guide line is that these courses are taught in an open laboratory environment and do not include programming.

Table 4.1-1 is a listing of present DPCS courses and their titles. Table 4.1-2 is a listing of other courses that use the computer extensively as well as those that use the computer in a few specific assignments.

In addition, a number of secretarial sciences courses use CPT Word Processors. These courses are also listed in Table 4.1-2.

4.2 Computer Science Department

The Computer Sciences Department is a part of the Science Division. Mathematics, Chemistry, Physics, Engineering, and Computer Science operate under one Department Chairman. There are two full-time computer science instructors. Numerous part-time instructors are employed for teaching evening and specific language courses. While such a situation is not optimum, the department screens part time instructors and maintains tight control over teaching philosophy, methodology and course content.

The Business Division and Computer Sciences Department maintain a close working relationship. Our only computing laboratory is housed in the Business Division building. This laboratory is manned by one paraprofessional from computer science and one from business. Further, the Business Division has just employed a full time staff member whose task is to integrate computer technology into existing academic courses. It is expected that this integration will concentrate in the business area initially but will then branch out to include the entire campus.

Secretarial Sciences maintains a separate lab that serves their word processing needs.

4.3 Present Systems

At present, academic computing is accomplished by use of micro computers for most courses. Fortran and Cobol are taught through use of terminal and modem connections to WSU. However, even these courses use the micro computer for initial off-line composition of programs which are then transmitted via software to WSU.

All but two micro systems are housed in one computer laboratory facility in the Business Division. The laboratory is open from 7:30 a.m. to 9:30 p.m. Monday through Thursday, closes at 4 p.m. on Friday and is open Saturday mornings. The center has available student aids and paraprofessionals at all times. The equipment in the lab is detailed in Table 4.3-1.

Table 4.3-2 provides a listing of the courses that presently use the computing center. Each listing shows an estimate of the number of students in that course for Winter quarter 1983 and an estimate of the number of terminal hours required per student. For those courses that use WSU, the hours of micro computer time needed for offline entry are listed separately from WSU computer time. All language intensive courses (including assembler) make use of the computing laboratory in the Business Division.

A laboratory specific to the Microprocessor Programmer vocational curriculum also exists. This laboratory has one functioning IBM personnal computer and various non-functioning donated systems. The laboratory is used for lectures and microprocessor (chip) projects.

A microcomputer is also used in the Chemistry Department as part of several lab experiments. This computer is 10 years old and has only tape cassette entry capacity.

4.4 Analysis of Present Systems

Figures 4.4-1 thru 4.4-3 detail the growth in computer related courses over the last several years. The growth in the last two years has been phenomenal.

From Table 4.4-2 and as shown in 4.4-3 for Winter quarter 1983, over 12,000 terminal hours were required (excluding word processing). Each micro was available for 700 hours, thus 17 micros were necessary at 100% utilization. (Twenty-three units were actually available.) This of course, implies that each micro could be used in each course which is not the case. COBOL and FORTRAN students use the Apples, GBUS 110 use the CPTs, others use only the Model I TRS-80, etc.

Clearly our present system is inadequate today without even addressing near term future needs.

TABLE 4.1-1
DPCS COURSES

COURSE NUMBER	TITLE
INTRO & LANGUAGE COURSES:	
DPCS 100	Survey of Data Processing
DPCS 101	Technicial intro to DP
DPCS 171	Micro Assembly
DPCS 231	COBOL
DPCS 232	Advance COBOL
DPCS 241	FORTRAN
DPCS 242	Advance FORTRAN
DPCS 251	BASIC
DPCS 252	Advance BASIC
DPCS 253	Disk BASIC
DPCS 281	PASCAL
MICRO VOCATIONAL COURSES:	
DPCS 160	Intro to microprocessors
DPCS 161	Electronics survey
DPCS 162	Electronics circuits
DPCS 260	Microprocessor architecture
DPCS 261	Microsystems Development & Testing
DPCS 265	System Documentation & Design
DPCS 266	Work Experience
DPCS 267	Work Experience
DPCS 269	Micro Thesis

TABLE 4.1-2
COMPUTER USAGE COURSES

COURSE NUMBER	TITLE
BUSINESS LAB	
GBUS 109	Desk Top Computer
GBUS 110	Desk Top Software
GBUS 111	Desk Top Software
ACTG 210	Computerized Accounting
Secretarial Science - Word Processing	
SSCI 102	Typing
SSCI 103	Typing
SSCI 201	Advance Typing
SSCI 245	Machine Transcription
SSCI 262	Word Processing
SSCI 263	Word Processing

TABLE 4.3-1
COMPUTER EQUIPMENT
BUSINESS BLDG ROOM 136

QT	MODEL	BRAND	FUNCTION
1	4051	Tektronix	microcomputer
1	LA 180	Digital Decwriter	printer
1	TeleComputerII	Digi-Log	terminal
2	LA 36	Digital Decwriter II	terminal
6	TRS-80 Model I	Tandy Radio Shack	microcomputer
9	TRS-80 Model III	Tandy Radio Shack	microcomputer
6	Apple II	Apple	microcomputer
2	Apple II Plus	Apple	microcomputer
1	8000	CPT	word processor/ microcomputer

TABLE 4.3-2
WINTER QUARTER 1983
COMPUTER COURSES
TAUGHT AND SUPPORTED BY
BUSINESS COMPUTER CENTER

Course Number	Course Title	Number of Students	Average Microcomputer Hours/Student	Mainframe Hrs/Students
DP/CS 100	Survey DP	79	6	
DP/CS 101	Tech Intr DP	86	10	
GBUS 109	Desk Top Computers	252	15	
GBUS 110	Desk Top Software	52	15	
GBUS 111	Desk Top Software	44	15	
ACCT 210	Comp. Acct	34	30	
DP/CS 231	Cobol	34	30	10
DP/CS 241	Fortran	38	30	10
DP/CS 251	Beginning Basic	80	26	
DP/CS 252	Advance Basic	61	31	
DP/CS 253	Disk Basic	16	30	
Self Support classes		60	15	

TOTAL STUDENTS 836

FIG. 4.4-3

COURSES-IN OR THAT-USE TERMINAL/MICRO/WORD PROCESSORS
HOUR DEMAND PER QUARTER

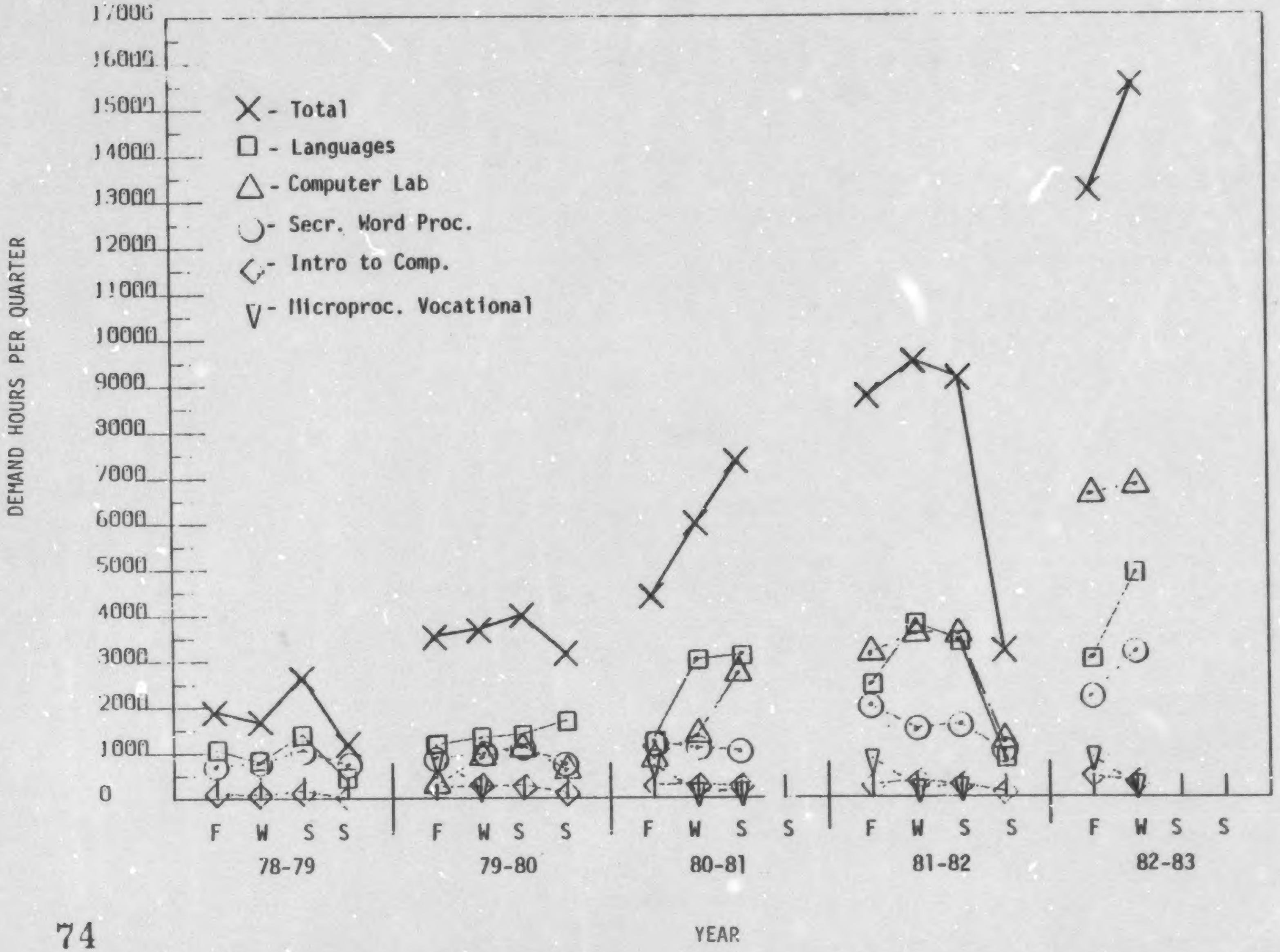


FIG. 4.4-2

COURSES-IN OR THAT-USE TERMINAL/MICRO/WORD PROCESSORS

YEARLY FTE'S

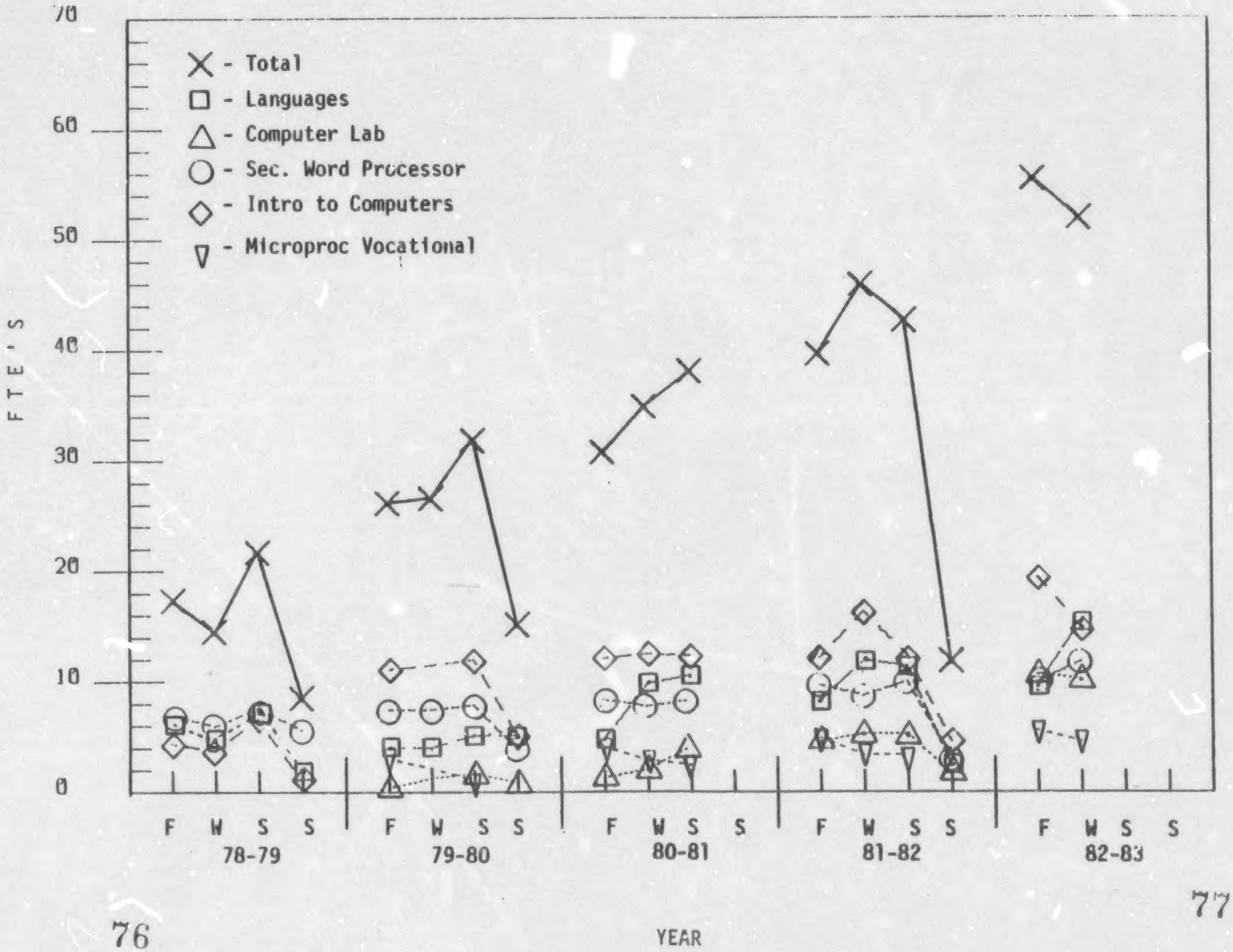
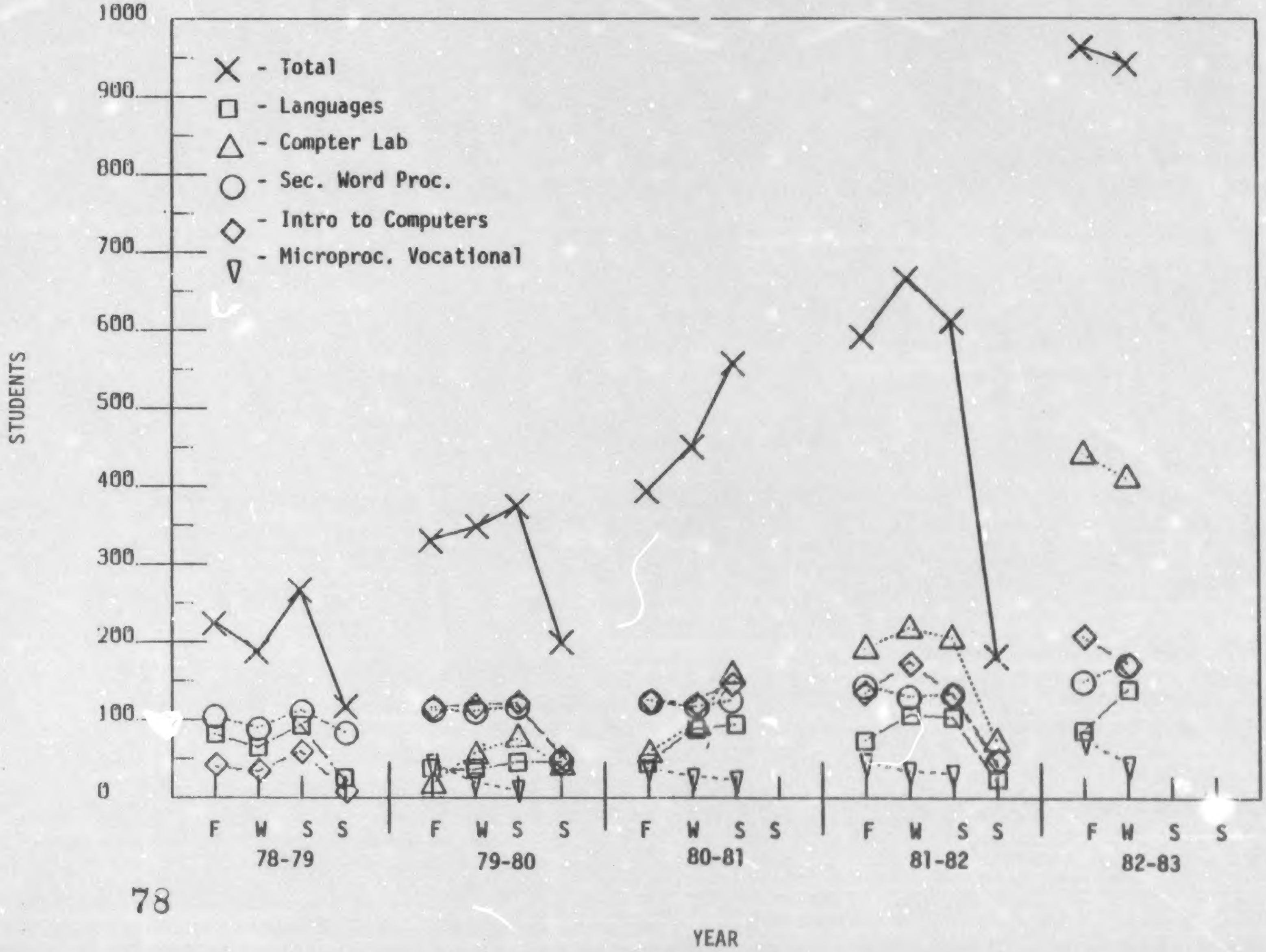


FIG. 4.4-1

COURSES-IN OR THAT-USE TERMINALS/MICROS/WORD PROCESSORS

NUMBER OF STUDENTS



5.0 Present Extension Services Computing Environment

Extension services offer some non-credit computer literacy and BASIC programming courses throughout the district. The extention department has 9 micro computers at a site east of Spokane, there are 10 or so micro's at Colville, 3 at Fairchild, and Farm Management has 3 devices. Micro's for courses at locations other than the sites mentioned must be transported or the use of existing high school facilities must be made. For the most part, computing courses are available only to people in fairly close proximity to Spokane or at local high schools with existing micros.

6.0 A Proposed System

6.1 Design Philosophy

As has been indicated, there are many needs for a computer system at SFCC. Such a system must be capable of growth. Generally, institutions have installed computer systems and within a year or two have exceeded the capabilities of the system. Thus, another computer has been needed very shortly. This has happened most recently at Gonzaga and EWU. We should plan initially for such an event.

The system must be designed for easy expansion. DEC and PRIME approach this problem from two different philosophies. DEC simply adds another machine in parallel to the old one (in the VAX line). PRIME makes a CPU and memory modification to upgrade a present computer to the next higher line. The essential feature is that either method allows the user to continue on as before using all existing software.

All mini's are susceptable to overloading with certain kinds of tasks. EWU reports that there is a simple 200 line BASIC program game that will bring the VAX to its knees. Evidently this program contains just the appropriate mix of input/output and math to cause VAX to slow up. Others report that the PRIMEs can be slowed up by extensive printing. Every mini system seems to have trouble if executing several COBOL jobs at the same time.

Conversely, most minis seem to be able to handle word processing and most BASIC programs with little difficulty.

The system proposed here and that is shown at the beginning of the report, separates computer tasks among a micro net, a mini system, and a major host computer such as the WSU-Amdahl. It is assumed that a local area net of micro computers would handle introductory computing tasks. These tasks would include BASIC simulations and enrichment exercises of an introductory nature, beginning BASIC programming, some simple text editing, and possibly text editing functions that could be transferred to the mini system for subsequent use or transfer to WSU.

The mini system would be used for communications and support via ports to the six counties and the WSU host computer, for test data bases, for extensive text editing and word processing, and for larger simulations. It could also be used for mini assembler. Later it would serve as a major tie-in to specialized devices in CAD/CAM, extended graphics, and classroom displays that are too demanding for the micro systems.

In particular, it is not anticipated that the mini system would be used extensively for high level language applications that could best be handled by a large mainframe. For this and for future information dispersal applications, a strong tie-in via leased line communications must be made to WSU. An eventual tie-in to EWU, Gonzaga, and other systems should be anticipated.

6.2 System Components and Design Requirements

6.2.1 General Description

The proposed system (see figure at the beginning of report) consists of three major parts and an existing computer controlled telephone system. The telephone system is capable of high speed data communications throughout the district and, it is assumed, could be used for high speed communications to outlying centers in the district.

6.2.2 Super Mini Subsystem and Conventional Net Terminal

The general requirements for the super mini system have been developed throughout this report. These requirements are summarized below. The mini computer:

1. must be capable of handling 60 dumb terminals initially and expandable to nearly 200 terminals (depending on micro computer and dumb terminal mix);
2. must be capable of 20 megabytes of on line storage - this is no problem with today's minis;
3. initally should have 1 megabyte of main memory--expandable to 4 megabytes;
4. must be capable of spooling jobs and handling transfers and retrievals via a 2400 to 9600 baud line to WSU-Amdahl, EWU-VAX, and eventually HP systems;
5. must be capable of supporting graphics and must be compatible with CAD/CAM (There are software CAD/CAM standards now available through the National Bureau of Standards. The system must be friendly to these standards and must be able to drive high resolution graphics display terminals.);
6. must be capable of at least 10 communications ports initially and expandable to 20 and must be compatible with the PRIME 2250 telecommunications controller;
7. must be capable of interfacing with a micro computer net (This may be by incorporating the net within the mini system or by enabling communications between the net controller and the mini. The goal is to be able to down load and up load data sets to the micro net hard disk and individual micro net units.);
8. A version of the mini systems word processing software must be transferable to the micro net so as to provide close simularity of operation of the micro net units and the mini terminals;
9. sufficient software must be supplied to accomplish the above functions, plus a Data Base Management System for the instructional and computing functions previously identified.

6.2.3 Local Area Net (LAN)

The local area net is envisioned as a net of micro computers spaced around the campus. Each micro computer must be able to utilize the storage capacity of the local area net's hard disk or its local floppy disk.

The goal would be to place multiple usage programs, simulations, relatively small data bases, and a common text processor on the hard disk rather than to have these items on floppy disks at each micro.

Loose coupling of the LAN to the mini computer will enable use of the micro computers for text composition that can be transferred to the mini system. Thus, each unit of the LAN could essentially be used as an intelligent terminal in the mini system. This feature will enable significant multiple usage capability of the micro units that will otherwise not exist.

A less favorable but viable option would be to enable each micro to be switched out of the LAN and turned into a dumb terminal hooked to the mini system. This could be accomplished with a software switch. The drawback is that each switchover then adds to the number of terminals that the mini system must be able to handle. If the mini system accesses the LAN hard disk rather than the individual units, the LAN units do not act as terminal loads to the mini computer.

A summary of the LAN requirements is as follows. The LAN system must be:

1. capable of handling 150 micro computers (several systems exist that can handle 200);
2. capable of working with Apples, TRS-80's, IBM personal, and CP/M based micro computers (Several nets are available that can do this by modifying the existing micro with an adapter board-cost about $600/board);
3. capable of working with units spaced up to a total distance of 2 km;
4. capable of a 20 megabyte hard disk initially--expandable to 40 megabytes;
5. capable of down loading programs, word processing, text and data files to each micro unit;
6. capable of up loading programs, text, and data files to the hard disk;
7. capable of communicating with the mini systems' disk storage.

8. capable of uploading and downloading at a maximum of 30 seconds access time.

6.2.4 Communications Network

A modern high speed communications system is essentially in place within District 17. The only assurances that need be made are that the controller unit can work with the mini system in accessing various ports.

The outlying communities will need communications of data at varying speeds. Initially conventional line speeds of 300 BAUD may be adequate. Certainly for temporary installations this would be the case. As sites grow in permanancy, data transfer needs and complexity of services, then permanent high speed data lines may be necessary. Probably 2400 BAUD lines would serve most functions.

A 2400 BAUD leased line with WSU will be used initailly. As the need grows, this may be expanded to a 4800 or 9600 BAUD capability.

6.2.5 Specialized Equipment

By some estimates, the reasonably priced CAD/CAM work station is about two years away. Almost everyone agrees that the major problem is with software and data communications standards. A reasonably priced work station is thought to be $10,000 to $20,000. Such a station would enable 3-D graphics, solids representation, drafting, etc.

It is too soon to estimate the extent to which the SFCC system will provide these capabilities. At least for now, large capability CAD/CAM requires special stand-alone computers that have some degrees of communications capability. Again standards are the big problem.

For now, this report by-passes this problem--simply stating that our system must have the capability to expand into these areas.

7.0 System Costing

In preparing computer acquisition plans, the state computing authority directs that three systems be evaluated. This will be done later, perhaps, when there is an integrated District 17 computing plan and the total district resorces avalable for such a system are identified. Thus, this report presents but one of the three approaches that may need to be investigated. It is offered as a starting point, but the proposed approach seems to be a sound one for at least two good reasons.

First, a significantly lesser system will simply not meet our needs. Using only micro computers and purchased time with WSU is becoming overwhelmingly difficult with our present demand. Continuation of this method will also not allow full development of the extended district.

Second, the proposed system does not try to "overkill" by attempting to fullfil those computing functions that a mainframe does best. Even if we tried such a tactic, the long range mission of providing information through WSU as a primary source would dictate close connection via telecommunications with them. Costing such an "overkill" approach would obviously show a greater expense than the proposed system. For instance, a 2400 BAUD leased line to WSU costs about $300/month. High level COBOL and FORTRAN jobs will cost about $.25 per job. A monthly cost for three classes of high level language including leased line and job costs will be about $600. Conversely, the purchase of high level compilers (COBOL, FORTRAN, PASCAL) will cost about $25,000 with $200/month maintenance. Five years would be required to amortize the compiler costs. Considering the other aspects of the problem such as obtaining newer up-to-date compilers (WSU has five versions of FORTRAN and two or three versions of COBOL with a new version of COBOL due out in a year or so), the slow down in operation of the mini system (thus requiring a bigger system sooner), the many other languages possible (SPSS, SNOBOL, LISP), and the various information data bases available, makes the argument for the proposed approach overwhelming.

7.1 Particulars of Costing

There are, at present, many unknowns in costing the proposed system. In particular, where will it be housed? are additional personnel needed or can present district personnel be used? what site preparation costs will be incurred?

Again this report side-steps the issue and concentrates on hardware/software costs only. But even with regard to this aspect, some rather broad guesses are made. Some of these guesses follow. All of these costs assume educational discounts.

ASSUMED COSTS

ITEM	COST
60 terminal capability one megabyte mini system (excluding terminals)	$100K to $120K
Maintenance (mini system)	$500/month
Expansion to 120 terminals and 4 mega byte memory	$120K
Additional maintenance (may not need terminal maintenance)	$600 month
Dumb terminal (each)	$1K to $1.2K
Micro computer (already adapted for micro net) (each)	$2.5K
Word processor (each)	$8K to $10K
CRT display	$.5K
Character printer (each)	$.5K
Line printer (300 LPM)	$8K
Graphics display (each)	$3K
LAN (including 20 megabyte disk, driver, software)	$10K
Modification of existing micro for LAN	$.5K
Necessary software	$10K to $20K/year
WSU leased line	$300/month 2400 BAUD $600/month 4800 BAUD

These assumptions along with the previously identified computing needs are used in Table 7.1-1 to detail a cost schedule for the first five years of acquisition for the new system. A total cost of $1.3 million is projected for the next 5 years.

TABLE 7.1-1
ESTIMATED COST

ITEM	YEAR 1	 2	 3	 4	 5
CAMPUS:					
Mini System (operating system included)	$120,000.00		$120,000.00		120,000.00
Dumb Terminals	36,000.00 30 units	36,000.00 30 units	36,000.00 30 units	36,000.00 30 units	30,000.00 30 units
Micro Net	10,000.00		3,000.00		
Adapting present micro	20,000.00 40 units				
Micro's and Word Processor	45,000.00 (2WP)(15MC)	70,000.00 (2WP) (20MC)	66,000.00 (2WP) (20MC)	53,000.00 (1WP) (20MC)	45,000.00 (1WP) (15MC)
Printers	7,500.00 15 units	5,000.00 10 units	5,000.00 10 units	5,000.00 10 units	5,000.00 10 units
Displays TV & High Resoln.	15,000.00 5 units	15,000.00 5 uints	15,000.00 5 units		
Software	25,000.00	15,000.00	15,000.00	15,000.00	15,000.00
Maintance	6,000.00	8,000.00	12,000.00	14,000.00	20,000.00
WSU:					
Leased line	3,600.00	3,600.00	7,800.00	7,800.00	7,800.00
Computing service	2,000.00	2,500.00	3,000.00	3,000.00	3,500.00
EXTENSON:					
Micro's	50,000.00 20 units	50,000.00 20 units	50,000.00 20 units	50,000.00 20 units	50,000.00 20 units
OTHER:					
WSU services etc.	1,000.00	1,200.00	1,500.00	1,750.00	2,000.00
Special Devices	0	?	?	?	?
TOTAL	$341,100.00	206,300.00	334,500.00	185,750.00	298,300.00

Five year Total
$1,365,950.00

BIOMEDICAL TECHNOLOGY

Biomedical Technologies

Medicine and engineering have together applied their respective disciplines to the art of "healing with technology". The effects of high technology can be seen in all aspects of medicine. Take for example,

-Bart Zoltan, an electrical engineer at Lederle Laboratories has developed a device known as a Compliance Aid for Pharmaceuticals (CAP). It is designed to keep patients on appropriate medication schedules. The device is a bottle cap that fits onto a standard size medication container. Built into the cap is a digital readout which displays the date and time the cap was last replaced. Then another dose is taken, the readout on the cap then changes to the new time of cap replacement. The cap is reusable on any bottle.

-At the Pennsylvania State University Biomechanics Laboratory, an Exercycle complete with force-measuring sensors, is the embodiment of high technology applications in medicine. The motions of the body during bicycling can be measured by high speed photography. The machine concentrates on the technique and strength of the body as it moves. On a video monitor, a pattern appears in the shape of a pinwheel which indicates how much force a rider is delivering to the pedals at each phase of the rotation. The raw data which measures movement is analyzed by another computer. Motion and the use of particular muscles are then adjusted. Although this machinery is currently being used primarily by athletes, the applications with handicapped individuals and others with muscular problems look promising.

-Doctors are now using a technique called "medical imaging", a small scanning device that can project images of any organ system without intruding into body tissue. Huntington Memorial Hospital in Pasadena, California became the first medical center in the country to routinely use a machine called a nuclear magnetic resonance scanner (NMR). It is capable of delivering detailed color renderings of the brain and other parts of the body without X-Rays. On the horizon are machines that can project images of the heart by harmlessly slicing the heart electronically into four sections and watching the action of the valves inside the heart on a monitor. This is done without pain or exploratory surgery. It is hoped that the NMR scanner will be able to identify "tissue signatures" in the heart, brain and arteries that signal future developments such as a heart attack or stroke that could be months away. In the future, doctors will be able to carry hand-sized ultrasound instruments that will replace stethoscopes, thus permitting physicians to study patterns in the heartbeat which are analyzed by a computer no larger that a pocket calculator.

-Health Occupations personnel are being trained and provided with continuing education courses through a laser disc education system. A disc system called the Miles Learning Center is educating through simulation. A patient on a television screen describes her ailments. The viewer can watch and listen as though the patient were in the room. The scene is interrupted and the viewer is asked to make decisions concerning further information and diagnostic tests which must be scheduled. The computer then acts a a quizmaster continuing to elicit decisions from the viewer until a diagnosis is made. The computer can then tell the viewer what the likely outcome of the dicisions would be.

There are also programs on the disc system which simulate infectious diseases that can become epidemics but are rarely seen, even by experienced physicians. Medical personnel participate in a simulation and gain some experience in dealing with potentially fatal situations. This system is also being used to provide medical personnel in remote areas with current information on medical research.

Education and Training

Technical innovations in the field of medicine have created a number of new occupations and a variety of new job skills that incorporate "high tech" applications. One such field is Medical Electronics Technician or, Biomedical Technician. Programs designed to train these technicians need to prepare students to repair, calibrate and evaluate the performance of electro-mechanical equipment used in the medical fields. Students need to receive a strong background in electronics and the sciences as well as related training on biomedical equipment such as cardiac monitors, defibrillators, respiratory therapy apparatus, incubators, electric beds and surgical lights.

Employment

Most jobs in this field are currently in hospitals. Graduates of these programs are also employed by medical instrument manufacturers. They install and maintain equipment once it is sold to a hospital. Those graduates with a background in education might also be asked to train staff on the use of the equipment.

References

Aaronson, Steve Pedaling for Gold Technology Illustrated Vol 3(19) pp. 52, 54-5

Rodenstein, Judith Emerging Careers: The Consequences of High Technology in Microcomputers: Applications in Vocational Education edited by Rodenstein, J. and Lambert, R. Madison, Wisconsin: University of Wisconsin Vocational Studies Center, 1983

Author Unknown Digital Medication Reminder Technology Illustrated Vol 3(10) October 1983 p. 4

PROGRAM: Biomedical Equipment Technology Program
INSTITUTION: Owens Technical College
Oregon Road
Toledo, Ohio 43699
(419) 666-0580
CONTACT PERSON(S): Gerald Bryant or Paul Svatik
DEGREE: Associate in Applied Science Degree
(4 semesters)
PROGRAM BEGAN: Mid 1970's

History

In the mid-1970's managers from several area hospitals approached the college with a need for biomedical equipment technicians. An advisory committee was established which has since played a key role in developing the program objectives and curriculum. A survey was initially conducted at local hospitals. It then became clear that there were many jobs available for graduates of a biomedical equipment technology program. The advisory committee supplied the curriculum and equipment.

The Program

The biomedical equipment major is one major in the Electricl/Electronics Technology program. The program objective is to educate competant technicians who can repair, calibrate, and evaluate the performance of electro-mechanical equipment used in the medical field. Students receive a strong background in electronics and the sciences as well as pertinent training in various areas of biomedical equipment. Students entering the program must be proficient in chemistry or they need to take an introductory chemistry course. Other prerequisites are physiology and anatomy.

The progream is [illegible] as a day and evening course for full or part-time students. Coursework is not solely in the biomedical field. A background in electronic engineering technology is first needed. The student then takes the two biomedical courses. A listing of the courses taken during the four semester program follow.

1st Semester	Class Hrs/Wk	Credit Hrs
DEV 100 College Orientation	1 lec	1
MTH 111 Technical Mathematics I	4 lec	4
EET 101 Circuit Analysis I	3 lec 3 lab	4
LSC 111 Basic Science I	3 lec 3 lab	4
EGS 115 Engineering Data Analysis and Programming	2 lec 6 lab	4
		17

	2nd Semester	Class Hrs/Wk	Credit Hrs
MTH 112	Technical Mathematics II	4 lec	4
EET 102	Circuit Analysis II	3 lec 3 lab	4
LSC 112	Basic Science IIA (12-1/2 Wk Module)	3 lec 3 lab	3
ENG 111	Composition I	3 lec	3
EET 110	Electronics	2 lec 3 lab	3
			--
			17

	3rd Semester	Class Hrs/Wk	Credit Hrs
EET 202	Digital Systems	3 lec 3 lab	4
EET 201	Digital Circuits	3 lec 3 lab	4
EET 211	Electronic Circuits	3 lec 3 lab	4
EET 250	Biomedical Fundamentals	3 lec 3 lab	4
ENG 112	Composition II	3 lec	3
			--
			19

	4th Semester	Class Hrs/Wk	Credit Hrs
EET 212	Electronic Systems	3 lec 3 lab	4
PST 111	Industrial Psychology	3 lec	3
- -	Engineering Tech Elective*	3 lec 3 lab	4
EET 251	Biomedical Clinical Laboratory	6 lab	2
ENG 130	Technical Writing	3 lec	3
SPE	Speech (101) or Conference Methods (210)	3 lec	3
			--
			19

*They recommend that biomedical students take the folowing course as an elective:

HSC 100	Interdisciplinary Health Concepts	2 lec	2

Total Credit Hours Required 74

The syllabi for the Electronic Engineering Technology courses which are required for the Biomedical Equipment Technology program follow.

SYLLABUS FOR FALL SEMESTER, 1983

COURSE NAME: Circuit Analysis I	INSTRUCTOR: Paul Svatik
COURSE NUMBER: EET 101	OFFICE: Eng Faculty Ofc
CREDIT HOURS: 4	OFFICE PHONE: 666-0580 Ext 264
LECTURE HOURS: 3	HOME PHONE: 882-0820
PREREQUISITES: High School Algebra	OFFICE HOURS: T.B.A.

DISCLAIMER:

The instructor reserves the right to amend, adjust, or otherwise modify this syllabus at any time during the semester.

TEXTS:

1. Introductory Circuit Analysis, Fourth Edition, Boylestad.
2. Introductory Circuit Analysis, Fourth Edition Lab Manual, Boylestad/Kousourou.

OBJECTIVES:

1. To learn basic DC theory applicable in all electronic courses.
2. Familiarize the student with typical laboratory equipment.
3. Develop and improve the student's analytical problem-solving skills.

COURSE DESCRIPTION:

Circuit Analysis I, Lecture 3, Lab 3, four credits, normally offered Fall and Spring. An introduction to the basic theorems of Circuit Analysis. Included are the principles of voltage, current, power, resistance, capacitance, inductance, and network analysis theorems. The laboratory experiments are designed to verify and reinforce concepts presented in class and to introduce the student to measuring instruments such as VOM's, DVM, oscilloscope, and impedance bridge.

GRADING PROCEDURES:

Grading Method and Evaluation

Class	80%	Quizzes	60%
		Final	20%
Laboratory	20%	Weekly Work	15%
		Lab Final/Project	5%

			100%
Instructor Discretion		+ 0-5%	

The instructor reserves the right to increase the student's average from 0 to 5%. This will be based on attendance, class participation, project, and the degree the instructor feels the student has applied himself.

Example:

	Class		Lab	
	Quizzes	Final	Labs	Final
	90	80	70	90
	95		80	
	80		Absent(0)	
	70		90	
	80		90	
	85		80	
	95		70	
	60		90	
	70		100	
	60		85	
	20		90	
	Absent(0)		70	
	90		80	
	100		90	
	70			
	-----		-----	
Total	1,065		1,085	
Average	71		77.5	

Class:

Quiz Average 71 x .6 = 42.6
Final 80 x .2 = 16

Lab:

Weekly Work 77.5 x .15 = 11.625
Lab Final 90 x .05 = 4.5

Total point earned = 74.7
Instructor Discretion(0-5) = 2.0
Total course points = 76.7

70 - 79 = "C"

100 - 90 A
90 - 80 B
80 - 70 C
70 - 60 D

Calendar EET 101

WEEK	TOPIC	LAB TOPIC
1	Chapter 1 Units and Notation	Intro to Lab Intro to Lab Procedures Hand out Guidelines
2	Chapter 2 Current and Voltage	Experiment 1
3	Chpt 3, Resistance Chpt 4, Ohm's Law, Power and Energy	Experiment 2
4	Chapter 5 Series and Parallel Circuits	Experiment 3
5	Chapter 5 Series and Parallel Circuits	Experiment 4
6	Chapter 6 Series - Parallel Networks	Experiment 5
7	Chapter 9 Capacitors	Problem-Solving Lab
8	Chapter 9 Capacitors	Experiment 10
9	Chapter 10 Magnetic Circuits	Problem-Solving Lab
10	Chapter 10 Magnetic Ciurcuits	Problem-Solving Lab
11	Chapter 11 Inductors	No Lab (Thanksgiving)
12	Chapter 11 Inductors	Experiment 11
13	Chapter 7 Methods of Analysis	Experiment 6
14	Chapter 7 Methods of Analysis	Experiment 7
15	Chapter 8 Network Theorems	Experiment 8
16	Chapter 8 Network Theorems	Experiment 9
	Final Examination	

SYLLABUS FOR SUMMER, 1983

COURSE NAME: Circuit Analysis II	INSTRUCTOR: Paul Svatik
COURSE NUMBER: EET 102	OFFICE: Eng Faculty Ofc
CREDIT HOURS: 5	OFFICE PHONE: 666-0580 Ext 264
LECTURE HOURS: 4	OFFICE HOURS: T.B.A.

PREREQUISITES: Tech Math I, Circuits Analysis I
COREQUISITE: Tech Math II

DISCLAIMER:

The instructor reserves the right to amend, adjust, or otherwise modify this syllabus at any time during the semester.

TEXTS:

1. Introductory Circuit Analysis, Fourth Edition, Boylestad.
2. Introductory Circuit Analysis, Fourth Edition Lab Manual, Boylestad/Kousourou.
3. Optional: Student Guide to Accompany Introductory Circuit Analysis, Fourth Edition, Boylestad.

COURSE DESCRIPTION:

Circuit Analysis II, Lecture 4, Lab 3, Credit 5, normally offered Spring and Summer. A continuation of Circuit Analysis I. Classroom work will emphasize the theorems discussed in Circuit Analysis I and extend their applications to alternating current. The laboratory experiments are designed to verify and reinforce concepts presented in class with emphasis on the use of oscilloscope, signal generator, and basic measurement devices.

OBJECTIVES:

1. To learn AC circuit concepts which include selected topics such as AC voltage, generation, resonance, non-sinusoidal circuits, transformers, polyphase systems, two-part system parameters, computer use in circuit analysis.

2. To learn methods of circuit analysis as applied to AC circuits.

3. To learn basic AC measurement concepts.

4. To provide the student with exposure to additional laboratory equipment.

GRADING PROCEDURES:

See EET 101 Grading Procedures.

Calendar EET 102

WEEK	TOPIC	LAB TOPIC
1	Chapter 22 AC Meters	
2	Chapter 13 Sinusoidal Alternating Current	Lab #2
3	Chapter 13 Sinusoidal Alternating Current	Lab #3
4	Chapter 14 Phasors	Lab #4
5	Chapter 15 Series and Parallel Circuits	Lab #6
6	Chapter 15 Series and Parallel Circuits	Lab #7
7	Chapter 16 Series-Parallel AC Networks	Lab #8
8	Chapter 17 Methods of Analysis (AC)	Lab #5
9	Chapter 18 Network Theorems (AC)	Lab #9
10	Chapter 19 Power (AC)	Lab #1
11	Chapter 20 Resonance	Lab #10
12	Chapter 20 Resonance	Lab #11
13	Chapter 23 Non-Sinusoidal Circuits	
14	Chapter 24 Transformers	Lab #12
15	Chapter 25 Two-Part Parameters	
16	Review	

SYLLABUS FOR SPRING SEMESTER, 1984

COURSE NAME: Electronics	INSTRUCTOR: Paul Svatik
COURSE NUMBER: EET 110	OFFICE: CH145E
CREDIT HOURS: 3	OFFICE PHONE: 666-0580 Ext 264
LEC/LAB HOURS: 2/3	OFFICE HOURS: TBA
PREREQUISITES: EET 101	HOME PHONE:

DISCLAIMER:

The instructor reserves the right to amend, adjust, or otherwise modify this syllabus at any time during the semester.

TEXT:

1. Semiconductor Devices, Zenith/Heathkit Educational Systems, Prentice-Hall.
2. Electronic Test Equipment, Zenith/Heathkit Educational Systems, Prentice-Hall.

TOOL KIT REQUIREMENT:

Weller/Xcelite Model 250K (or equivalent)

DRAFTING TEMPLATES:

Electronic Drafting Templates ANSIY32.2 and Y32.14 (or equivalent)

PROJECT:

An electronic VOM project will be required of each student. The VOM kit will be available in the bookstore.

COURSE DESCRIPTION:

An introductory course to electronic semiconductor devices and laboratory test equipment for Engineering Technology students. A combined lecture/laboratory course in the study of semiconductor devices construction, characteristics, and operation. The course will also study the theory, operation, and functions of laboratory test equipment. Electronic drafting fundamentals will be presented.

OBJECTIVES:

Upon completion of this course the student will be able to:

1. Draw electronic schematics from a sketch to acceptable industry standards.
2. Explain basic diode operation.
3. Discuss the difference between the two types of bipolar transistors.
4. Identify and/or draw the different transistor amplifier configurations.
5. Identify various other transistors and semiconductor devices.
6. Explain the operation of various semiconductor devices.
7. Discuss the various operating modes of a VOM.
8. Explain the basic theory of a digital multimeter.
9 Identify the various controls of an oscilloscope.
10. Explain the operation of the various circuits in the oscilloscope.
11. Discuss the measurements and tests that may be performed with an oscilloscope.
12. Explain the basic operation of an electronic counter.
13. Identify the different signal generators.
14. Discuss the application of audio, RF, and function generators.
15. Discuss the principle operation of a power supply.
16. Explain how a transistor tester, curve tracer, spectrum analyzer, logic analyzer, and logic probe are used in the laboratory.
17. Display proficient use of the various laboratory test equipment.
18. Explain the function, discuss the theory and demonstrate hands-on capability of the above topics.

GRADING METHOD AND EVALUATION:

100 - 90 = A
80 - 89 = B
70 - 79 = C
60 - 69 = D
Below 60 = F

Quizzes - 30%
Midterm - 15%
Final - 15%
Laboratory - 35%
*Participation - 5%

*Participation will be an instructor discretion based on lab and class participation, how well the student handles the equipment, applies himself/herself, and attitude.

LABORATORY REQUIREMENT:

The student will draw a schematic and wiring diagram from a laboratory assignment handout provided by the instructor. The schematic and diagram must be completed and verified by the instructor before the student may begin the laboratory experiment.

Tentative Class Schedule

Week	
1	Essentials of electronic schematic drafting Reading assignment: None Lab: Given an engineer's sketch the student will draw a schematic diagram.
2	Semiconductor Fundamentals Reading assignment: Semiconductor Devices - Unit 1 Lab: To test a diode by means of an ohmmeter.
3	Diodes Reading assignment: Semiconductor Devices - Unit 2 Lab: To investigate the characteristics of a typical diode.
4	Zener & Other Diodes Reading assignment: Semiconductor Devices - Units 3 & 4 Lab: To demonstrate the characteristics of a zener diode and its applications.
5	Bipolar transistor operation Reading assignment: Semiconductor Devices - Units 5 & 6 Lab: To test NPN & PNP transistors. To investigate common-emiTter characteristics.
6	FET's and Thyristors Reading assignment: Semiconductor Devices - Units 7 & 8 Lab: To investigate the operation of a JFET, and UJT.
7	I.C.'s & Optoelectronic Devices Reading assignment: Semiconductor Devices - Units 9 & 10 Lab: To investigate the operation of a typical photo transistor.
8	Review and Midterm
9	Analog Meters Reading assignment: Electronic Test Equipment - Unit 1 Lab: To design and test a DC VOM
10	Digital Meters Reading assignment: Electronic Test Equipment - Unit 2 Lab: To investigate the characteristics of a DMM.
11&12 (11) (12)	Oscilloscopes Reading assignment: Electronic Test Equipment - Unit 3 Lab: To investigate the function and operation of the oscilloscope controls.
13	Frequency Measurements Reading assignment: Electronic Test Equipment - Unit 4

Lab: To investigate the function and operation of the frequency counter controls.

Week

14 Frequency Generators
Reading assignment: Electronic Test Equipment - Unit 5
Lab: To investigate the function and operation of the function generator controls.

15 Other Laboratory Equipment
Reading assignment: Electronic Test Equipment - Unit 6
Lab: To investigate the operation of an impedance bridge.

16 Review and Final Exam

Course Syllabus

Digital Circuits
EET 201

Prerequisites:	EET 101, EET 102		
Corequisites:		Year:	1983/84
Semester:	Fall	Lecture:	3
Credit Hr:	4	Office:	3
Instructor:	Ken Jenkins	Lab:	CH 145D
Phone:	666-0580 (299)	Hours:	As Posted

Note: When appropriate or necessary, the instructor reserves the right to amend, adjust, or deviate from this syllabus at any time during the semester. If and when changes are made the student is notified.

Description: Combined classroom/laboratory investigation of number systems, logic gates, MSI (medium scale integration) devices (counter, flip/flops, registers, encoders, decoders, and multiplexers), discrete devices used in digital circuits (L.E.D.'s solid state relays, RC timing components and transistors) and an examination of the major integrated circuit fabrication technologies. The laboratory portion of the course will involve the student in designing, assembling, testing and troubleshooting digital circuits of various types.

Objective: To provide the engineering technology student in electronics with basic background in the operation, analysis, testing and application of the technology of digital electronics and its use in industrial instrumentation, monitoring and control functions.

Text: Digital Fundamentals, 2nd Edition, Thomas L. Floyd, Merrill Publishing Co., (c) 1982

Materials: Digital logic symbols drafting template, a scientific calculator.

Grading: Tests, quizes and assignments are not curved. The final grade for the course is a composite which is based on the following percentages and proportionment.

A......90-100%
B......80- 90%
C......70- 80%
D......60- 70%
F......50- 60%

Lab assignments and experiments.......30%
Quizes..................................20%
Homework and/or other assignments.....10%
Midtern Examination...................20%
Final Examination.....................20%

Semester Schedule

Week #	Lecture Topic/Text & Problems
1	Introduction to course, Lab procedures and management, Digital vs. Analog, Circuit Integration, Breadboarding, Lab equipment. Chapter 1 (1-1 to 1-21)
2	Number systems and codes. Chapter 2 & Appendix C & D (2-1 to 2-44)
3	Logic gates. Chapter 3 & Appendix A1-A10 (3-1 to 3-35, A-1 to A-12)
4	Boolean Algebra, circuit minimization techniques. Chapter 4-1 through 4-5 (4-1 to 4-17)
5	Karnaugh Maps. Chapter 4-6 through 4-7 (4-18 to 4-26)
6	Combinational Logic. Chapter 5 (5-1 to 5-60)
7	Adders, Comparators, and decoders. Chapter 6-1 through 6-5 (6-1 to 6-20)
8	Review & Midterm Examination.
9	Multiplexers, demultiplexers, and additional combinational logic. Chapter 6-6 through 6-10 (6-21 to 6-34)
10	Flip/Flops, multivibrators, clocked circuits. Chapter 7 (7-1 through 7-3[illegible]
11	Counters, registers, Chapter 8-1 through 8-7 (8-1 to 8-30)
12	Registers. Chapter 8-8 through 8-14 (8-31 to 8-35)
13	Memory devices. Chapter 9 (9-1 to 9-31)
14	Buses, data conversion devices. Chapter 10-1 through 10-5 (10-1 to 10-16)
15	Introduction to digital system architecture. Chapters 11 & 12
16	Review and synthesis.

Final Examination

COURSE SYLLABUS

COURSE NAME: Digital Systems
COURSE NUMBER: EET 202
CREDIT HOURS: 4
LECTURE HOURS: 3
LAB HOURS: 3
SEMESTER: Fall, 1983

INSTRUCTOR: Ken Jenkins
OFFICE: CH
OFFICE PHONE: 666-0580 Ext 299
HOURS: As Posted
PREREQUISITES: EET 201, EGS 115
COREQUISITES:

DISCLAIMER:

When appropriate or necessary, the instructor reserves the right to amend, adjust, or deviate from this syllabus at any time during the semester.

TEXT:

Microprocessors and Microcomputers, 2nd Edition, Tocci & Laskowski Prentice-Hall, (C) 1982

OBJECTIVE:

To provide the electronics engineering technology student with a basic background in the application of digital circuit technology at the system level as represented in the microprocessor based microcomputer. To give the student experience with programming techniques and software development as it relates to the industrial application of computers.

COURSE DESCRIPTION:

Combined classroom/laboratory investigation of digital systems. The course involves the study of the microprocessor based computer as an example of a digital system. Included in the course is a brief review of digital circuit fundamentals and digital number systems. Such topics as computer system architecture, memory organization and management, programming languages and techniques, I/O strategies, interfacing and timing, troubleshooting and system peripheral device (such as printers, plotters, disk drive, etc.) are examined during the course of study. Basic machine language and assembler language programming are also presented.

GRADING:

Tests, quizzes and assignments are not curved. The final grade for the course is a composite which is based on the following percentages and proportionment.

A...........	90 - 100%
B...........	80 - 90%
C...........	70 - 80%
D...........	60 - 70%
F...........	50 - 60%

Lab assignments and experiments......	30%
Quizzes..............................	20%
Homework and/or other assignments....	10%
Midterm Examination..................	20%
Final Examination....................	20%

Week	Lecture Topic	Text
1	Introduction to course, lab, and materials.	Preface
2	Numbering systems and codes.	Chpt 1, pp 3-25
3	Review of digital circuits. Parallel vs. serial transmission. Combinational logic, IC fabrication technologies.	Chpt 2, pp 26-34
4	Dynamic circuits, clocks and system timing, tristate logic. Flip/flops and registers, buses and bus control.	Chpt 2, pp 35-58
5	Memory devices and memory architecture. Basic system architecture. Bits, bytes, nibbles and other things that go bump in the night.	Chpt 2, pp 59-72
6	Device addressing and operating cycles.	Chpt 3, pp 75-99
7	Microcomputer programming, high level languages (compilers & interpreters), assembly language, and machine language, monitors.	Chpt 4
8	Review & Midterm Examination	
9	The microprocessor instruction set. Assembler/Editor concepts.	Chpt 8
10	Comparing microprocessors. Programming models. Multiprecision. More instructions & addressing modes.	Chpt 5
11	Programming techniques and debugging in assembly language. More instructions & addressing modes.	
12	Hardware and software design for control & monitoring applications. Interfacing.	Chpt 6
13	Hardware and software design for control & monitoring applications. Interfacing.	Chpt 7
14	Peripheral devices, stepper motors, robots, data converters, I/O of various types.	Chpt 7
15	More on peripherals. Disk storage systems.	Chpt 7
16	Review and synthesis.	
	Final Examination	

COURSE SYLLABUS

COURSE NAME: Digital Circuits
COURSE NUMBER: EET 201
CREDIT HOURS: 4
LECTURE HOURS: 3
LAB HOURS: 3
SEMESTER: Fall, 1983

INSTRUCTOR: Ken Jenkins
OFFICE: CH 145D
OFFICE PHONE: 666-0580 Ext 299
HOURS: As Posted
PREREQUISITES: EET 101, EET 102
COREQUISITES:

DISCLAIMER:

When appropriate or necessary, the instructor reserves the right to amend, adjust, or deviate from this syllabus at any time during the semester.

TEXT:

Digital Fundamentals, 2nd Edition, Thomas L. Floyd,
Merrill Publishing Co., (C) 1982

MATERIALS:

Digital logic symbols drafting template.
A scientific calculator.

OBJECTIVE:

To provide the engineering technology student in electronics with a basic background in the operation, analysis, testing and application of the technology of digital electronics and its use in industrial instrumentation, monitoring and control functions.

COURSE DESCRIPTION:

Combined classroom/laboratory investigation of digital circuits. The course includes a study of digital number systems, logic gates, MSI (medium scale integration) devices (counters, flip/flops, registers, encoders, decoders, and multiplexers), discrete devices used in digital circuits (L.E.D.'s, solid state relays, RC timing components and transistors), and an examination of the major integrated circuit fabrication technologies. The laboratory portion of the course will involve the student in designing, assembling, testing and troubleshooting digital circuits of various types.

GRADING

A.........	90 - 100%
B.........	80 - 90%
C.........	70 - 80%
D.........	60 - 70%
F.........	50 - 60%

Lab assignments and experiments......	30%
Quizzes................................	20%
Homework and/or other assignments....	10%
Midterm Examination..................	20%
Final Examination....................	20%

Week	Lecture Topic	Text & Problems
1	Introduction to course, lab procedures and management, digital vs. analog, circuit integration, breadboarding, lab equipment.	Chapter 1 (1-1 to 1-21)
2	Numbering systems and codes.	Chapter 2 & Appendix C&D (2-1 to 2-44)
3	Logic gates.	Chapter 3 & Appendix A1-A10 (3-1 to 3-35, A-1 to A-12)
4	Boolean algebra, circuit minimization techniques.	Chapter 4-1 thru 4-5 (4-1 to 4-17)
5	Karnaugh maps.	Chapter 4-6 thru 4-7 (4-18 to 4-26)
6	Combinational logic.	Chapter 5 (5-1 to 5-60)
7	Adders, comparators, and decoders.	Chapter 6-1 thru 6-5 (6-1 to 6-20)
8	Review & Midterm Examination	Review
9	Multiplexers, demultiplexers, and additional combinational logic.	Chpt 6-6 thru 6-10 (6-21 to 6-34)
10	Flip/flops, multivibrators, clocked circuits.	Chapter 7 (7-1 to 7-34)
11	Counters, registers.	Chapter 8-1 thru 8-7 (8-1 to 8-30)
12	Registers.	Chpt 8-8 thru 8-14 (8-31 to 8-39)
13	Memory devices.	Chapter 9 (9-1 to 9-31)
14	Buses, data conversion devices.	Chpt 10-1 thru 10-5 (10-1 to 10-16)
15	Introduction to digital system architecture.	Chapters 11 & 12
16	Review and synthesis.	
	Final Examination	

ENGINEERING TECHNOLOGY
COURSE OUTLINE

COURSE NAME: Electronic Circuits
COURSE NUMBER: EET 211
CREDIT HOURS: 4
LECTURE HOURS: 3
LAB HOURS: 3
PREREQUISITE: EET 102

INSTRUCTOR: Ahmad Ghasemy
PHONE: 867-0711

COURSE DESCRIPTION:

A lecture-laboratory course covering electronic devices such as diodes, bipolar transistors and fieled-effect transistors, their characteristics and application in rectifiers, voltage multipliers, regulators, clamping circuits and amplifiers.

TEXT:

Electronic Devices and Circuit Theory, Third Edition. Robert Boylestad and Louis Nashelsky, McGraw-Hill, 1982.

OBJECTIVES:

General:

To provide the student with a background in semiconductor electronic devices for application in their future employment in a technical field.

SPECIFIC LEARNING:

The student will learn:

1. Semiconductor theory as it relates to energy levels.
2. Define bipolar and semipolar devices.
3. Describe forward and reverse bias of a pn junction.
4. Discuss the different rectifiers and application of diodes.
5. Discuss the different types of diodes.
6. Identify clipper, clamper, multiplier, and detector circuits.
7. Discuss regulator diode required for power supply regulation.
8. Discuss bipolar transistor and biasing needed for conduction.
9. Identify the four transistor biasing circuit and transistor configuration.
10. Identify characteristics and biasing requirements for bipolar transistor amplifier.
11. Difference between JFETs and MOSFETs.
12. Biasing techniques for field effect-transistor.
13. Class A and B amplifiers.

EVALUATION:

Student evaluation will be based upon exams. Exams and quizzes will constitute 60% of the final grade with 4% for homework and laboratory experiments and 0-10% for instructor discretion.

90 or above	A
80 - 89	B
70 - 79	C
60 - 69	D
Below 59	F

The instructor reserves the right to increase the student's average from 0 to 10%. This will be based on attendance, class participation, project, and the degree the instructor feels the student has applied himself.

EXAMS:

There is a quiz every two weeks and a final exam. (There is a possibility for a quiz every week.) If any student misses the class, he has the responsibility to find out about quiz on Friday. There is no makeup test for missed tests.

COURSE CONTENT:

Week 1

Chapter 1	Introduction
	Atomic structure
	Energy level
	n type material
	p type material
	Idel diode

Week 2

Chapter 1	Basic Characteristic
	No bias
	Reverse bias
	Forward bias
	Zener region
	Silicon, Germanum diode
	Reverse recovery time
	Heat sink

Week 3

Chapter 1	Power curve
	Diode specification sheets
	Diode arrays - integrated circuits
	Static resistor
	Dynamic resistor
	Average AC resistor

Week 4

Chapter 1	Diode circuits Clippers Clampers Rectifier Half-wave rectifier Full-wave rectifier

Week 5

Chapter 2	Zener diode The zener regulator Voltage regulator Power diodes Photodiode Light-emitting diode Liquid crystal Thermistors

Week 6

Chapter 3	Introduction Transistor Transistor operation Amplifying action Common Base circuit

Week 7

Chapter 3	Common emitter Common collector Transistor maximum rating Specification sheet

Week 8

Chapter 4	DC biasing Operating point Common bias circuit Common emitter circuit Input section Output section Bias stabilization

Week 10

Chapter 4	DC bias circuit Input section (base-emitter loop) Output section (base-emitter loop) Approximate analysis DC bias voltage feedback

Week 11

Chapter 4
Common collector emitter-follower
Input section
Output section
Graphical DC bias
Design of DC bias circuit
Different biasing circuits

Week 12

Chapter 5
FET (field effect transistor)
Characteristics
Transfer characteristic
JFET parameters
MOSFET characteristics

Week 13

Chapter 6
FET biasing
Fixed bias
JFET amplifier
Voltage divider biasing
DC biasing

Week 14

Chapter 7
Small signal analysis
Transistor modeling
Transistor hybrid circuit
Variation of the parameters
Small-signal analysis
Voltage gain
Current gain
Power gain
Phase relationship

Week 15

Chapter 8
FET, small signal analysis
Amplifier with source resistor
Theory of amplifier
Decibel and power relation
Concept of amplifier

Week 16

Chapter 8
Class of amplifiers
Harmonic distortion
Class A amplifier
Class B amplifier
Push-pull amplifier
Review

ELECTRONICS LAB

Week 1	Orientation Measurements and elements in electronics lab
Week 2	Measurement with oscilloscope
Week 3	Junction-diode characteristics Diode biasing
Week 4	Zener diode characteristics
Week 5	Half-wave and full-wave rectifiers
Week 6	Bridge rectifier and filter
Week 7	Voltage multipliers
Week 8	Clippers circuit
Week 9	Clamping action
Week 10	Transistor biasing
Week 11	Common base configuration
Week 12	Voltage-divider and emitter bias
Week 13	Base-driven amplifier
Week 14	Class A amplifier
Week 15	Class B push-pull amplifier
Week 16	Final project

ENGINEERING TECHNOLOGY
COURSE SYLLABUS
FALL, 1983

COURSE NAME: Biomedical Fundamentals
COURSE NUMBER: EET 250
CREDIT HOURS: 4
LECTURE HOURS: 3
LAB HOURS: 3
PREREQUISITE: None

INSTRUCTOR: Paul Svatik
OFFICE: Engineering Faculty Office in College Hall
OFFICE HOURS: As Posted

DISCLAIMER:

When appropriate or necessary, the instructor reserves the right to amend, adjust or deviate from this syllabus anytime during the course.

OBJECTIVES:

General:

To provide the student with an orientation to the working environment of the biomedical equipment technician. An exposure to the various kinds of equipment that the biomedical equipment technician will encounter in future employment.

Specific:

The student should be able to:

1. Identify the various physiological variables that can be observed in the human body and how they are detected.
2. Explain electrocardiography and how an electrocardiogram is recorded.
3. Identify the lead configurations in electrocardiography.
4. Explain the difference between direct and indirect blood pressure measurement.
5. Draw the block diagrams of a monitoring system with various parameter to be monitored.
6. Discuss the difference between respiratory therapy and diagnostics.
7. Explain how monitoring of a patient can be achieved without connection to a monitor.
8. Discuss electrical safety and the care of equipment to prevent safety hazards.
9. Explain how x-rays are generated and the techniques required to produce an x-ray image.
10. Converse in medical terminology along with technical language.
11. Discuss how computers are an aide in biomedical instrumentation and various usea of computers.

TEXT:

Cromwell, Leslie, Weibell, Fred J., Pfeiffer, Erich A., Biomedical Instrumentation and Measurements, 2nd Edition, Prentice-Hall, 1980.

EVALUATION

Student evaluation will be based upon performance on examinations, quizzes, homework, and laboratory reports (class participation, attendance, etc., may also be used). The student should achieve a minimum of 60% for passing the course.

GRADING POLICY:

Homework	20%
Quizzes	25%
Laboratory	25%
Exam	30%

TENTATIVE ASSIGNMENT SCHEDULE

Week 1	Intro to Biomedical and Transducer Chapters 1 & 2 Lab Experiment: Transducer Handout, Experiment #1
Week 2	Sources of Potentials and Electrodes Chapters 3 & 4 Lab Experiment: Electrodes, Investigation, Design & Build Quiz #1
Week 3	Cardiovascular System Chapter 5 Lab Experiment: Blood Pressure Measurement "In-vivo" Simulation
Week 4	Cardiovascular Measurements Chapter 6 Lab Experiment: ECG Handout, Experiments #2, #3 Quiz #2
Week 5	Patient Care and Monitoring Chapter 7 Lab Experiment: ECG Amp., Handout, Experiment #4
	EXAM #1
Week 6	Measurement in Respiratory Chapter 8 Lab Experiment:
Week 7	Noninvasive Diagnostics Chapter 9 Lab Experiment: Temperature Handout, Experiment #5 Quiz #3
Week 8	Nervous System Chapter 10 Lab Experiment: Nerve Stimulator, Handout, Experiment #6
Week 9	Sensory Measurements Chapter 11 Lab Experiment: GSR Handout, Experiment #7 Quiz #4
Week 10	Telemetry Chapter 12 Lab Experiment: Audiometer Handout, Experiment #8
	EXAM #2
Week 11	Clinical Lab Equipment Chapter 13

Lab Experiment:

Week 12 X-ray
Chapter 14
Lab Experiment: Speaker and Tour of Rad. Tech.
Quiz #5

Week 13 Computers in Biomedical
Chapter 15
Lab Experiment: Speaker

Week 14 Electrical Safety
Chapter 16
Lab Experiment: Report (NFPA 76 BT) (NFPA 51), Safety Test Lab and Equipment

Week 15 Medical Terminology
Lab Experiment: Report

Week 16 Summary of Biomedical

EXAM #3

ENRICHMENTS:

Student enrichment will include a tour of a local hospital's biomedical department. Outside speakers on x-ray systems and computerized monitoring may be included.

ENGINEERING TECHNOLOGY
COURSE SYLLABUS
SPRING, 1983

COURSE NAME: Electronics Systems	INSTRUCTOR: Joe P. Elmers
COURSE NUMBER: EET 212	OFFICE: Eng. Faculty Office
CREDIT HOURS: 4	OFFICE HOURS: As Posted
LECTURE HOURS: 3	OFFICE PHONE: 666-0580 Ext 399
LAB HOURS: 3	
PREREQUISITE: EET 211, MTH 112	HOME PHONE: 874-2061

DISCLAIMER:

When appropriate or necessary, the instructor reserves the right to amend, adjust, or deviate from this syllabus anytime during the course.

COURSE DESCRIPTION:

A continuation of electronic circuits illustrating the use of circuit principles as they apply to complex circuits. The student will investigate amplifiers, both discrete and integrated, frequency response, gain, coupling techniques, power requirements and power supplies. System characteristics will be confirmed by observation and measurement in the laboratory.

OBJECTIVES:

General:

To provide the student with a background in electronic systems such as: feedback networks, oscillators, voltage regulators, modulators and integrated circuitry; as they apply to the student's future employment in the technical electronics field.

Specific:

The student will be able to:

1. Calculate decibels, Miller resistance and capacitance.
2. Explain the frequency effects of lead and log networks as well as amplifier response to frequency.
3. Describe the procedure of making integrated circuits and their operations.
4. Calculate amplifier gain with different feedback circuits.
5. Identify and explain different oscillator circuits.
6. Draw the schematic or schematics for several different voltage regulator circuits, namely the zener regulator, the feedback regulator, series pass regulator and with current limiting.
7. Identify different op-amp circuits, (I.E., componants, amplifiers, vco, integrators).
8. Explain the frequency domain versus the time domain.
9. Explain how intermodulation and mixing is accomplished.
10. Describe and draw the block diagrams of an AM and FM receiver.
11. Discuss the different types of vacuum tubes and their applications.

TEXT:

1. Boylestad, Robert. Electronic Devices and Circuit Theory, 3rd Edition, Prentice Hall, Inc., 1982
2. Malvino and Johnson, Experiments for Electronic Principles, 2nd Edition, McGraw-Hill, 1979.

EVALUATION:

Student evaluation will be based upon exams, quizzes and laboratory experiments. Exams and quizzes will constitute 80 percent of the final grade and 20 percent for laboratory experiments.

GRADING POLICY:

25% - Laboratory
70% - Exams
0-5% - Instructor Discretion

A - 90 - 100
B - 80 - 89
C - 70 - 79
D - 60 - 69
F - Below 59

The instructor reserves the right to increase the student's average from 0 to 5 percent. This will be based on attendance, class participation, project, and the degree the instructor feels the student has applied himself.

LABORATORY PROCEDURE:

Students will follow the laboratory manual with experiments for the course, performing experiments that follow the topic or topics discussed.

TENTATIVE ASSIGNMENT SCHEDULE

Week 1	FET Circuit Analysis Chapter 14 Homework Assignment: All Odd Problems Lab Assignment:
Week 2	Decibels, Miller Theorem Hybrid Parameters Chapter 15 Homework Assignment: All Odd Problems Lab Assignment: 31, 32
Week 3	Frequency Effects Chapter 16 Homework Assignment: All Odd Problems Lab Assignment: 33, 34, 35
Week 4	Integrated Circuits Chapter 17 Homework Assignment: All Odd Problems Lab Assignment: 36, 37
Week 5	Negative Feedback Chapter 18 Homework Assignment: All Odd Problems Lab Assignment: 38, 39
Week 6	Negative and Positive Feedback Chapters 18 & 19 Homework Assignment: All Odd Problems Lab Assignment: 40, 41
Week 7 & Week 8	Positive Feedback Chapter 19 Homework Assignment: All Odd Problems Lab Assignment: 42, 43, 44
Week 9	Voltage Regulation Chapter 20 Homework Assignment: All Odd Problems Lab Assignment: 46, 47
Week 10	Op-Amp Application Chapter 21 Homework Assignment: All Odd Problems Lab Assignment: 48, 49
Week 11	Frequency Domain Chapter 22 Homework Assignment: All Odd Problems Lab Assignment: 50, 51

Tentative Assignment Schedule (continued)

Week 12 & Week 13	Intermodulation and Mixing Chapter 23 Homework Assignment: All Odd Problems Lab Assignment: 52
Week 13	Modulation Chapter 24 Homework Assignment: All Odd Problems Lab Assignment: 53
Week 14	Modulation Chapter 24 Homework Assignment: All Odd Problems Lab Assignment: 54
Week 15	Vacuum Tubes Chapter 25 Homework Assignment: All Problems Lab Assignment:
Week 16	REVIEW FINAL

SYLLABUS FOR SPRING, 1983

COURSE NAME: Biomedical Clinical Lab
COURSE NUMBER: EET 251
CREDIT HOURS: 2
LEC/LAB HOURS: 0/6
PREREQUISITES: EET 250

INSTRUCTOR: Paul Svatik
OFFICE: Eng. Faculty Office
OFFICE PHONE: 666-0580 (204)
HOME PHONE: 882-0820
OFFICE HOURS: TBA

DISCLAIMER:

The instructor reserves the right to amend, adjust, or otherwise modify this syllabus at anytime during the semester.

TEXTS:

1. Clinical Engineering: Principles and Practices, Webster/Cook.
2. Introduction to Biomedical Equipment Technology, Carr and Brown.

There will also be required reading of various service and operator manuals from time to time on various pieces of equipment.

COURSE DESCRIPTION:

An on-campus and on-site laboratory study of the biomedical equipment profession. The student will observe the operation of a biomedical department under the supervision of a clinical engineer or senior BMET. The student will also receive "hands-on" experience doing P.M.'s, calibration, safety checks and repairs of various biomedical equipment on campus.

OBJECTIVES:

1. To learn the overall philosophy of a Biomedical Engineering Department.
2. To learn the importance of documentation and how it is done.
3. To perform preventative maintenance, calibrations, and safety inspections on biomedical equipment in the laboratory.
4. To improve the student's troubleshooting skills in repairing biomedical equipment.
5. To increase the student's background with various pieces of testing equipment.

GRADING PROCEDURES:

Grades will be based upon the amount of equipment serviced and number of reports turned in and based upon the hours the student applies himself/herself to the projects. There will also be quizzes based upon the reading assignments.

LABORATORY TOPICS:

1. Pasco ECG System - get it operating.
2. G.E. 3100 B.P. AMP - cal and check out.
3. G.E. Defibrillator - repair, calibrate, and safety test.
4. Dallons Cardiac Monitor - check, repair, and safety.
5. Ivac 400 check out.
6. Air shields B.P. AMPS.
7. Travenol Hemodialysis Machine.
8. Electrodyne Resp and H.R. Monitor.
9. C.F. Monitors.
10. Monoghan Pulmonary Function Analyzer.

The following items are in the Nursing Skills Lab, Preventative Maintenance, and safety checks to be performed.

1. Gomco Vacuum Suction.
2. Jobst Rotating Tourniquets.
3. Bird Mark 14 Ventilator.
4. Air Shield Isolette.
5. IVAC 230
6. Abbott Life Care Pump.
7. Vacu-Aide Suction.
8. Devilbiss Suction Pump.
9. Devilbiss Humidifier.
10. IVAC Electronic Thermometer.
11. Tempspar Electronic Thermometer.
12. American Seating Electric Bed.
13. Devilbiss Mini-Dop 610 Doppler.
14. Med-Sonics Doppler.
15. Tyco Mercury and Aneroid Monometers.
16. Laerdal Recording Resusi-Annie.
17. Welch Allen Opthalmoscope

Other laboratory experiments may be supplemented.

Equipment

The advisory committee has donated most of the equipment. There are many health occupations programs on the Owens campus, so much of the equipment is already on campus and thus available for program uses. In the electronics lab, there is standard electronics equipment. In addition, there are cardiac monitors, defibrillators, telemetry, respiratory therapy apparatus, infusion pumps, hemodialysis, incubators, electric beds, surgical lights, electro surgical units, blood pressure equipment, and radiology equipment.

Faculty

There is only one full-time faculty person in the department who was hired specifically for the program. Other faculty in the electronics program have also taken his courses in order to become familiar with this new high tech field. The instructor is a Degreed and Certified Biomedical Equipment Technician. He received a Bachelor of Science Degree in Industrial Technology and a Master of Science Degree in Education. He has been certified by the Association for Advanced Medical Instrumentation (AAMI) in Arlington, Virginia. In order to receive certification an individual must pass a written exam and have two years of work experience in a biomedical field.

Placement

Most graduates are hired as biomedical technicians. Approximately 90% of the graduates work in hospitals and 5-10% work in industry as general engineers or field service technicians. In general, graduates can expect to service all equipment in the medical areas. They are usually working under a clinical engineer. In the program at Owens, 90% of the students that do internships are successful in obtaining a position in the biomedical field.

PROGRAM: Biophotography Program
INSTITUTION: Bellevue Community College
3000 Landerholm Circle S.E.
Bellevue, Washington 98007
(206)641-0111
CONTACT PERSON: Jim Bennett
DEGREE: Associate of Arts Degree
DATE BEGAN: Fall 1969

History

The Biomedical Photography Program was started in 1969 with four students. Of the four, one graduated and is still working at the University of Washington. Curriculum was based on a basic Associate of Arts Degree with several classes in photography added. The students were brought into the VA Hospital in Seattle for practical work under Mr. Joe Mineo. The program stuggled along under several part-time coordinators, using associate faculty from institutions in the greater Seattle area as "instructors".

In 1974 a grant was obtained from the VA Manpower Commission. The purpose of the grant was to hire a full-time clinical instructor as a role model and program coordinator. The grant also provided for some equipment to loan to the hospitals and institutions who were supporting the program. The grant also provided for some equipment to loan to the hospitals and institutions who were supporting the program as clinical facilities. The equipment was purchased early in 1975 and issued to the departments. The clinical instructor hired for Fall Quarter 1974 rewrote the curriculum to match the requirements of the Biological Photographic Association Board of Registry.

Advisory Committee

The associate faculty was brought in as the first advisory committee, and most are still functioning as such. This committee is currently being reorganized.

Program

The program is a two-year Associate Degree program. Currently, there are no courses offered part-time at night for professionals to upgrade skills. Future plans include adding this option to the curriculum.

Teaching Techniques

Similar to any other photography class, theory is offered in a classroom setting and practical work in labs. The technical nature of the program requires many hours in the lab. Textbooks are always a problem in that there are none that deal specifically with the profession. A bibliography is furnished by the Biological Photographic Association and many of the books are good, however some are now out of print. Much of the curriculum is designed to support the Registered Biological Photography (RBP) study guide compiled by the Board of Registry of the Biological Photographic Association.

Objectives

Upon completion of the Biophotography Program, students will:

1. Select and use proper equipment for best results.
2. Know photographic films and papers, selecting specific materials to match the assigment requirements.
3. Know correct darkroom procedures to make films and papers respond to the best advantage.
4. Take necessary precautions in photographing contagious or sterile subjects.
5. Know stucture and function of organs and systems of the human body.
6. Photograph special surgical procedures in the operating room.
7. Produce photomicrographs and photomacrographs of histological slides and minute specimens.
8. Keep accurate records necessary for medical-legal cases.
9. Evaluate and use good methods of displaying finished work.
10. Layout and prepare simple charts and graphs.
11. Asemble photographs and art work for clear illustration of subject.
12. Operate basic video camera and recording equipment.
13. Use basic motion picture equipment and have a good understanding of production techniques.
14. Be fully qualified to step into full-time employment as a biophotographer.

Equipment

The program when initiated was sandwiched into the existing photolab. The equipment already on hand was and is still shared. When the VA Grant was received in 1974, some funds were set aside for equipment. The items were very basic and were used to supplement those already in use. Equipment is acquired at the present time through College Instructional Equipment funds as they are available.

Job Placement

Job opportunities are referred to the college by outside employers, and members of the Biological Photographic Association (which operates a job hot-line). Most of the employment opportunities are located outside of the state, though graduates continue to get jobs in the local area.

PROGRAM: Diagnostic Ultrasound Technologist Program
INSTITUTION: Bellevue Community College
3000 Landerholm Circle S.E.
Bellevue, Washington 98007
(206)641-2316
CONTACT: Anne Colwell
DEGREE: Associate of Arts Degree
DATE BEGAN: Fall 1978

History

The Diagnostic Ultrasound Technologist Program was started in 1978 with 10 applicants. The first year applicants were accepted from the following health care professionals only:

Registered Nurses
Radiologic Technologists
Medical Technologists
Medical Nuclear Technologists
Physician Assistants

Six of the original applicants accepted into the program graduated and are presently Diagnostic Ultrasound Technologists working in various sections of the world. A graduate from this first year class was one of the first sonographers working in Saudi Arabia from the United States. Curriculum was based on seven quarters of physics and scanning and techniques in the ultrasound field. The first three quarters the students attended laboratories, with hands on experience using machines on the college campus to scan phantoms. The students began their off-site clinical training under the supervision of an experienced ultrasound technologist or physician. In addition to clinical education, the students attended night classes in a variety of ultrasonic applications. These classes were taught by a practicing sonographer in the area. The overwhelming support received from the clinical affiliates in the community was and still remains vital to the success of the program. The program came into existence solely by the support of the college and demand from the community. To meet this demand, the program recruiting base was expanded and opened to qualified applicants in the community not previously involved in the health care profession. Curriculum then became based on a basic Associate of Arts Degree. Twenty-five credits in various social and physical sciences were required before entering the ultrasound program Total ultrasound credits required were 82. In Fall of 1983, the curriculum was revised. Pre-requisites emphasize biological sciences and two years of ultrasound courses. Ultrasound courses only, total 96 credits.

Advisory Committee

The advisory board consists of associated faculty, community physicians and sonographers, and interested consumers.

The Program

The Diagnostic Ultrasound Technologist Program of Bellevue Community College is planned according to the guidelines established by the American Medical Association Council on Medical Education, the American Institute of Ultrasound in Medicine, and the American Society of Ultrasound Technical Specialists.

The purpose of the two-year program is to provide didactic education and practical experience as preparation for diagnostic ultrasound technology. Students attend classes on campus during the first year of the program The second year of the program, students have clinical experience in a medical facility working with an ultrasound technologist (sonographer) for 36 hours per week for 48 weeks. The Diagnostic Medical Sonographer with the direction and supervision of a doctor of medicine or osteopathy, assists in gathering data, planning sonographic techniques and performing scanning to provide information relative to diagnosis of patient health care needs or problems.

Theory is taught in the classes on campus. We emphasize hands-on techniques while the student is still taking courses on campus. Each ultrasound course requires a "live Lab" in which the students must conduct and report several developed experiments. Each quarter a writing course is scheduled to gain skills in research and documentation and presentation. A full year of full time clinical practical work experience in four separate ultrasound disciplines (abdomen, OB-GYN, Echocardiography and Vascular) is gained at various clinical facilities. Much of the curriculum is designed reflecting the Society of Diagnostic Medical Sonographers (SDMS) study guide recommended by the Association of Registered Diagnostic Medical Sonographers.

Equipment

A Real-Time Ultrasound unit was purchased out of program funds. Two B-Scan units were donated to the college. The department has always shared dark room equipment with the Radiologic Technology Program. We are budgeting for more equipment in the future.

Job Placement

We do not offer a formal job placement program To date, all graduates of the program are employed in ultrasound full or part time.

Laser Technology

Definitions

The laser was first introduced in 1960. "Laser" is an acronym for Light Amplification by Stimulated Emission of Radition. This means that light can be amplified (given extraordinary energy) by stimulating electrons into the emission (release) of radiation (light energy). This process results in a powerful beam of light.

The "laser of today" is composed of captured light energy, bounced between mirrors and then released as an intense, concentrated light. There are many different kinds of lasers. Each shines at its own brilliant wavelength. In fact, there are over 200 different types of lasers and numerious variations of each type. That is what makes them so versatile.

Applications

Lasers are used in a number of occupations because they perform a variety of tasks better or more efficiently than more traditional job tools. Examples include:

-a surgeon's "scalpel of light" which is used for delicate surgery inside the eye and destroying kidney stones, cysts and tumors. Lasers can also cauterize as they cut (the heat actually seals off small blood vessels), and thus reduces bleeding during surgery

-a hologram (3-D image) which is created by splitting a laser beam. Holographic optics are starting to replace glass mirrors, lenses in printers and photocopy machines, and will soon be used for 3-D television. They can also be used to create unique designs and colored effects for musical laser light shows and art forms.

-applications in the field of telecommunications such as transmitting high rates of noise- free information through fiber cables

-applications in manufacturing such as welding, drilling, cutting, heat treating, scibing and marking metals, plastics, wood, paper ceramics, and cloth. Lasers make very powerful cutting tools and are especially useful in the diamond cutting business and steel industry. A new laser welding system has been recently developed. It is composed of two lasers, two computer-controlled welding stations and a load/unload robot. It was designed to be fully automated and to use lasers to complete all the welding. Laser welding will allow tracking of irregularly shaped joints at high speeds and is therefore particularly efficient. A robot is stationed between the two systems and is called by them when required. It is useful for high volume production of complex assemblies, particularly when combined with an automated controller and LOAD/UNLOAD system.

-retail businesses are using lasers in point-of-sale equipment to read optical codes marked on products. This application has automated the check-out at supermarkets and department stores.

-computers will eventually be based on an integrated optical circuit system, revolutionizing the industry.

-scientific applications such as that developed at Los Alamos National Laboratory in New Mexico. It includes a laser-based analysis system that can determine the elemental composition of molten steel. The technique used is known as LIBS-Laser Induced Breakdown Spectroscopy. It uses a commercial laser to deliver pulses of light lasting less than a micro-second. The light reduces the material to its elemental constituents. The plasma is then ana-used to analyze constituents of coal gasifier effuents and blood samples.

Training and Job Development

There are three major career clusters directly related to laser technology:

1) physicists who generally work in research and developments, and investigation,
2) engineers who apply the principles of physics to the practical design and operation of equipment. They design or modify laser equipment or components and direct the manufacturing and/or testing of laser systems.
3) Laser Electro Optics Technicians (LEOT's) are the specialists who make laser equipment work and keep it in working order. They are trained in the principles, procedures and techniques of electrical, electronic, mechanical, optical, fluid and thermal hardware devices. They are also experts on the mechanics of systems associated with lasers. Some technicians work under the direction of engineers and physicists and are associated with research, development and/or design. Others may work independently or in teams to operate, test, repair, modify and/or maintain laser equipment.

   LEOT's are trained in two or three year associate degree programs. In general, graduates of these programs are employed in constructing, repairing, testing, installing, modifying, programming, operating, and servicing industrial lasers and laser operated devices.

A survey completed by the American Electronics Association found that the demand for laser technicians is expected to grow 228 percent by 1985.

Continuing education programs are available for technicians who are transferring into laser/electro-optics from other technical fields. Courses might include:

- Laser Fundamentals and Systems
- High Energy Laser Systems
- Laser Safety
- High Power Lasers for Scientists and Engineers
- Laser Applications in Materials Processing
- Modern Optics
- Optical Fiber Communications
- Chemical Lasers

For more information about lasers contact the Laser Institute of America, 5151 Monroe Street Suite 118W, Toledo Ohio 43623

References

Baum, Rudy Laser applications Chemical Engineering News Volume 61 (34) August 22, 1983

Florida Vocational Journal Laser Burst of Technology Volume 8 (4) February/March 1983

Laser Institute of America Careers and Educational Programs in Lasers and Electro-Optics 1983

Miller, J.S. and Chevalier, J. Development of an automated laser beam welding facltity for high volume production Welding Journal Volume 62 (70) July 1983 pp.49-54

Moore, Bonnie Jo Working with lasers: A new job option for technicians Career World Volume 12 (3) November 1983 pp. 27-9

PROGRAM: Laser and Electro-optics Technology
INSTITUTION: Vincennes University
1002 N. First Street
Vincennes, Indiana 47591
(812) 882-3350
CONTACT: Dean Bill G. Spence
DEGREE: Associate of Science Degree (2 years)
DATE BEGAN: Courses began in 1975;
Degree program in 1978

History

The Laser Electro-Optical training program began at Vincennes University after two years of research. A five page questionnaire was sent to two hundred and fifty possible electro-optical, laser or optical users. The reponses overwhelmingly indicated that a program that taught practical electro-optical metrology was needed. In 1975, Vincennes University introduced a curriculum that would lead to an Associate of Applied Science Degree in Laser and Electro-Optical Technology. For the first two years, this degree was an option program in the Electronics Technology area. During this two year period, the Laser program went from three classes worth nine credit hours to five classes worth fifteen credit hours. In 1978, two more classes were added resulting in a total of 23 credit hours.

The first graduation class in 1977 had five graduates. The class of 1978 had four graduatuates. In 1980, there were 45 graduates. Currently, enrollment is limited to 65 students per year.

The Program

The objectives of the laser department curriculum are to provide students with basic knowledge about key areas and practical skills necessary to meet job-entry requirements as a laser electro-optical technician (LEOT). The key areas are electronics, lasers, optics, and electro-optics. The areas are presented in such a way that each area becomes a small part of a whole system, interfacing each area with one or more areas. The end result is a technician with a broad base on which to build. This makes it easier for a person to make job transitions throughout his/her career.

Every laser optics class offered at Vincennes University has a laboratory schedueld with it. Twice as much time is spent in the lab as in the classroom. The phenomena that are observed in the laboratory are explained in the lectures. This process trains a techncian who not only can produce desired results in a lab, but for the most part can explain why and how these results are or were obtained.

Each lab contains the most modern up-to-date equipment. This equipment is used by all students for hands-on training. As of 1983, the Laser Program has been housed in a new facility. This facility was designed and built for Laser Technology.

The students are an extremely varied group. Education backgrounds vary from high school credit by G.E.D. to Master's Degrees. Most students fall into one of the following three groups:

1. Recent high school graduates with no prior training or job experience in LEOT.
2. Veterans with electronics or related experience
3. Students with one or more years of college who have chosen technical training because it offers them better opportunities than a traditional college curriculum.

The curriculum of the LEOT Department is based on a national survey of laser and optics industries. An effort has been made to include all the tasks that are important for an LEOT to master. The basic two year curriculum contains no history, government or literature classes. It consists of eight LEOT courses (18 credits), five electronics courses (19 credits), two physics courses - geometrical wave optics and wave quantum optics (5 credit hours) and four courses from support areas (17 credits). This sequence leads to an Associate of Applied Science Degree.

The courses are listed in the order in which they are taken by the students.

LASER AND ELECTRO-OPTICS TECHNOLOGY
(53103)
A Two-Year Program
Leading to the A. S. Degree

Graduates are qualified as skilled technicians in the emerging technology of laser and electro-optics. Students learn to install, maintain and operate industrial equipment that utilizes lasers, electro-optics, and optics as principle components. Students are trained for jobs in design support, developmental assistance, sales, field service, and maintenance. From the manufacturing angle, they will be prepared for assembly, fabrication and testing. A math SAT score of 450 is required in order to complete the program in four semesters.

FIRST YEAR

		Sem I	Sem II
TLO 130	Laser Components	2	
TLO 140	Introduction to Lasers	3	
TEL 110	DC & AC Circuit Analysis	5	
TEL 125	Transistor Circuit Design	4	
SMA 102	College Algebra	3	
TLO 160	Laser Devices		3
TEL 170	Digital Systems & Computer Circuitry		5
HEW 101	English Composition I		3
SPH 107	Geometrical Optics		3
SMA 104	Trigonometry		3
		--	--
		17	17

SECOND YEAR

		Sem I	Sem II
TLO 230	Measurement & Holography	3	
TEL 230	Microprocessor Software & Interfacing	3	
SPH 108	Wave Quantum Optics	2	
	Humanities Elective	3	
	Social Science Elective	3	
	Physical Education Activity	1	
TLO 250	Optical Fabrications & Vacuum Systems		3
TLO 280	Laser Fabrications & Systems Maintenance		2
TLO 290	Applications and Pulsed Lasers		3
TLO 255	Industrial Electronics Control		3
	Social Science Electrive		3
	Physical Education Activity		1
		--	--
		15	15

NAME________________________
HOME
ADDRESS____________________

LASER ELECTRO-OPTICS TECHNOLOGY
GRADUATION REQUIREMENTS

Directions: Circle hours of courses you have taken or are taking, record grade

COURSE	HRS	GRADE
LASER ELECTRO-OPTICS TECH. (All 34 Hrs Required)		
TLO 140 Introduction to Lasers	3	
TLO 160 Laser Devices		
TLO 230 Laser Measurements & Holography	3	
TLO 250 Optical Fabrication & Vacuum Systems	3	
TLO 280 Laser Fabrication & Systems Maintenance	2	
TLO 290 Applications & Pulsed Lasers	3	
TEL 110 DC & AC Circuit Analysis	5	
TEL 125 Transistor Circuit Design	4	
TEL 170 Digital Systems & Computer Circuitry	5	
TEL 225 Industrial Electronics Control	3	
MATHEMATICS (Choose 6 Hrs)		
SMA 115 Intro to College Math	5	
SMA 102 College Algebra	3	
SMA 104 Trigonometry	3	
SMA 116 Survey of Calculus	5	
SMA 118 Calculus I	5	
SCIENCE (Choose 5 Hours)		
SPH 107 Geometric	3	
SPH 108 Wave Quantum Optics	2	

COURSE	HRS	GRADE
SOCIAL SCIENCE (Choose 6 Hrs)		
APS 141 Applied Psychology	3	
APS 142 General Psychology	3	
APS 145 Psychology of Child-Hood & Adolescence	3	
AEC 100 Elements of Economics	3	
AEC 201 Microeconomics	3	
AEC 202 Macroeconomics	3	
AEC 121 American Institutions	3	
AHI 131 Survey of European History	3	
HUMANITIES (Choose 6 Hrs) (HEW 101 Required)		
HEW 101 English Comp. I	3	
HEW 102 English Comp. II	3	
HEW 108 Technical Writing	3	
HEW 143 Speech	3	
PHYSICAL EDUCATION ACTIVITY (Choose 2 Hrs)		
INTRO TO COLLEGE LIVING	1	
MINIMUM HOURS REQ. FOR GRAD.	65	
ADD TOTAL HOURS		

LASER ELECTRO-OPTICS TECHNOLOGY

TLO 130 Laser Components — 2 hours (Sem I)

Properties and uses of filters, optical windows, beam splitters, stalongs, mirrors, polarizers, gratings, photographic supplies, non-linear materials, laser power meters. 2 hours lecture, 3 hours laboratory.

TLO 140 Introduction to Lasers — 3 hours (Sem I)

The elements of a laser, operation of a helium gas laser, laser physics, optical cavities, properties of laser light and a survey of laser systems. 3 hours lecture, 4 hours laboratory.

TLO 160 Laser Devices — 3 hours (Sem II)

Properties and uses of holographic equipment, photographic instrumentation, special purpose imaging devices, laser modulators, Q-switching devices, and the use of laser collimators and auto-collimators spatial filters, beam expanders and Farady isolators. 2 hours lecture, 3 hours laboratory.

TLO 230 Measurements and Holography — 3 hours (Sem I)

Prerequisite: SPH 107 & TLO 160. This course includes topics such as dispersion and refraction index measurements with prism/grating spectrometer, use of mono-chromators & spectrophotometers, use of interferometers, Q-switch graphic processes, including HNDT, time lapse, time average and multiple exposure. The set-up of holographic systems, processing and analysis techniques will be emphasized. 3 hours lecture, 5 hours laboratory.

TLO 250 Optical Fabrications & Vacuum Systems — 3 hours (Sem II)

The theory and practices of glass fabrication, grinding, testing, and thin film depositions. Theory of low pressure tube devices. The application and maintenance of vacuum systems. This class will emphasize hands-on-experiences with different laboratory equipment. 2 hours lecture, 3 hours laboratory.

TLO 280 Laser Fabrication and Systems Maintenance

2 hours (Sem II)

Prerequisite: TLO 140 & TEL 125. A course designed to enable the student to plan, disassemble, test and troubleshoot various laser and electro-optical systems. The practical utilization of support and test equipment will be emphasized. Laboratory exercises will be conducted with the student designing, building and testing a working laser on an independent basis. 3 hours lecture, 5 hours laboratory.

TLO 290 Laser Applications and Pulsed Systems

3 hours (Sem I)

Cutting, drilling, & welding with a laser, air pollution monitoring with lasers, data processing & data display, optical memories, holographic nondestructive testing, medical applications of lasers, rangine & angle tacking, optical communications systems. Ion gas lasers, molecular gas lasers, organic dye lasers, optically pumped cw & pulsed solid lasers. 3 hours lecture, 4 hours laboratory.

PHYSICS

SPH 107 Geometrical Optics 3 hours (Sem II)

Prerequisite: SMA 102. Corequisite: SMA 103 or SMA 104. This study of Classical Optics will include reflection, and refraction, Snell's Law, geographical ray tracing, critical angle, deviation, dispersion, displacement, image formation from spherical surfaces, thin lens imaging, graphical construction, magnification, thin lens combination, elementary optical systems, thick lens imaging, cardinal points, thick lens combinations, imaging from spherical mirrors, f-stops and apertures, and avverations. 3 hours lecture, 3 hours laboratory.

SPH 108 Wave and Quantum Optics 2 hours (Sem I, II)

Prerequisites: SMA 103 or SMA 104 and SPH 107 or consent of the instructor. This study of modern optics will include wave properties, superposition principle, interference, diffraction, single and multiple slits, defraction gratings, interferometers, electromagnetic properties of light, amplitude-intensity-energy relationships, sources, polarization, reflection and transmission from dielectrics and metals, Brewster's angle, Bohr atom, energy levels and spectra, frequency doubling, holography, wave-particle duality. 2 hours lecture, 3 hours laboratory.

ELECTRONICS

TEL 100 Introduction to Electronics Technology 3 hours (Sem I, II)

Course for non-Electronic majors exploring the basics of electronic circuitry and applications of electronics to radio, amplifiers, power supplies and television adjustment. 3 hours lecture, 6 hours laboratory.

TEL 110 DC and AC Circuit Analysis 5 hours (Sem I)

Develops an understanding of basic DC and AC theory with mathematical analysis. Emphasis is on the function and characteristics of components in basic circuit configurations, resonance, RCL circuits, vector analysis, and power supplies. 5 hours lecture, 10 hours laboratory.

TEL 120 Vacuum Tubes and Amplifier Design 3 hours (Sem I)

The design & study of vacuum tube circuits as applied to audio amplifiers. Emphasis is on characteristic curves, classes of amps, methods of coupling, bias techniques, etc. Lab work is centered around the design and construction of a vacuum tube HiFi amplifier. 3 hours lecture, 6 hours laboratory.

TEL 125 Transistor Circuit Design 4 hours (Sem II)

Transistor theory and design as applied to the three common transistor configurations, pulse applications and oscillators. Advanced circuitry such as complimentary-symmetry, quasi-complimentary, darlington compounds, and cascade preamplifiers are presented. The core of the course consists of the complete design and testing of a stereo amplifier and the fabrication techniques necessary to complete the project. 5 hours lecture, 6 hours laboratory.

TEL 170 Digital Systems & Computer Circuitry 4 hours (Sem II)

A course in digital electronics including binary numbers, codes, Boolean algebra, logic circuits, counters, registers & storage devices. Applications of complete systems such as digital volt-meters, frequency counters, digital clocks, serial & parallel mini-computers and microprocessors are constructed. 4 hours lecture, 7 hours laboratory.

TEL 230 Microprocessor Software Applications 3 hours (Sem I, II)

Corequisite: One of the following classes: SPH 101, SNT 150, BDP 114 or consent of the instructor. This course provides an introduction to microprocessors using specific devices & examples. Topics include specific architectures, instruction sets, assembly languages and programming techniques, high level language implementation, and applications. The student will gain laboratory experience with 8 bit microprocessors and an advanced 15 bit system. 3 hours lecture, 5 hours laboratory (arranged).

TEL 255 Industrial Electronics Control 3 hours (Sem I)

A course specializing in industrial systems & control techniques. Application include regulated power supplies, temperature systems, photo devices, motor control, magnetic amplifiers, synchro-systems, three phase power, etc. 3 hours lecture, 5 hours laboratory.

TEL 260 Microprocessor Hardware & Interfacing 2 hours (Sem I, II)

This course is to provide technical experiences in the construction, testing, debugging, and programming of a microprocessor. An understanding of architecture and hardware is developed in the construction of the system along with logic for interfacing and necessary programming for operation. 2 hours lecture, 3 hours laboratory.

BOOK LIST FOR

LASER ELECTRO-OPTICS PROGRAM

TECHNICAL EDUCATION RESEARCH CORPORATION MODULES used:

MODULE #	TITLE
1	Introduction to Lasers
3	Laser Technology
6	Laser Components
7	Laser Devices
9	Laser Projects
10	Measurements

An Introduction to Lasers & Their Applications by O'Shea, Gallen, Rhodes

Laser Technology by Hrand M. Munchergan

Home Grown Holography by T. Kallard

A study Guide on Holography by T. H. Jeong

Exploring Laser Light by T. Kallard

Gas Lasers by A. Bloom

Vacuum Technology by Guthria

Fundamentals of Optics by Jenkins & White

Introduction to Classical & Modern Optics by Meyer-Arendt

Introduction to Electronic Troubleshooting by Lenan

The Power Supply Handbook by Tab Books

TLO 140

INTRODUCTION TO LASERS

COURSE SYLLABUS

FALL SEMESTER, 1983

INSTRUCTOR: DAVID TYREE

COURSE OBJECTIVES:

To familiarize the student with basic laser operations, the language of lasers and electro-optics, calculations pertaining to laser physics; becoming adapt at working with low powered lasers and related components and hardware; how to use appropriate electronics in association with lasers and E-O devices; discuss jobs and expected salaries.

TEXT:

Course I, Laser/Electro-Optic Measurements, Waco:
Technical Education Research Center.

ASSIGNMENT SCHEDULE

WEEK	ASSIGNMENT
1	MODULE 3
2	MODULE 2
3	MODULE 1
4	MODULE 4
5	MODULE 5
6	MODULE 5
7	MODULE 6
8	Midterm
9	MODULE 7
10	MODULE 8
11	MODULE 8
12	MODULE 9
13	MODULE 10
14	MODULE 10
15	MODULE 11
16	Finals

GRADE EVALUATION:

12 labs at 20 points each	240
4 tests at 100 points each	400
Midterm exam at 150 points	150
Final exam at 200 points	200
Lab & Test Attendance	10

Total	1000

TLO 290

LASER APPLICATIONS & PULSED SYSTEMS

COURSE SYLLABUS

FALL SEMESTER, 1983

INSTRUCTOR: DICK DUESTERBERG
Office EB3; Phone 885-5294

COURSE DESCRIPTION:

Cutting, drilling & welding with lasers; photodetectors and imaging devices; non-destructive testing, non-contact gaging & inspection; optical data storage, fiber optics. 3 hours lecture, 4 hours laboratory.

COURSE GOALS/OBJECTIVES:

This course will address the following goals:
Performance Objectives may be found in Addendum A.

1. Define op amp terms
2. Identify op amp circuits
3. Define photodetector parameters
4. Describe position sensitive detectors
5. Measure photodiode responsivity
6. Determine position-sensitive photodiode linearity
7. Construct height gage
8. Construct laser alignment system
9. Explain photodiode array operation
10. Contrast linear detector arrays
11. Specify line scan camera
12. Determine filter spectral transmittance
13. Describe non-destructive testing techniques
14. Describe optical measurement techniques
15. Measure rod diameter
16. Measure surface roughness
17. Detect surface anomalities
18. Measure wire diameter using diffraction method
19. Describe laser material processing parameters
20. Calculate weld depth
21. Calculate focal diameter
22. Weld wires
23. Construct auto-focus device
24. Collimate laser device
25. Describe waveguide loss mechanism
26. Measure optical fiber attenuation
27. Describe waveguide dispersion mechanisms
28. Describe index profile measurement
29. Describe modal noise
30. Describe waveguide bandwidth measurement
31. Measure numerical aperature
32. Measure waveguide core diameter
33. Describe optical data storage
34. Describe a bit-oriented optical memory

COURSE REFERENCES:

Text:

Ready, John F., Industrial Applications of Lasers,
New york: Academic Press, Inc., 1978 Edition

COURSE EVALUATION:

There are 1120 possible points in this course. It takes 1030 points for an A, 918 points for a B, 784 points for a C, 616 points for a D. See Addendum B for a breakdown of points for exams and labs.

COURSE SCHEDULE:

This course will meet for 16 weeks.

ADDENDUM A

PERFORMANCE OBJECTIVES

1. Given a list of terms & without references, the student will define op amp terms. Performance will be satisfactory if definitions are consistent with a published document.

2. Given schematic drawings, the student will identify op amp circuits. Performance will be satisfactory if:

   A) Circuits are correctly identified
   B) The transfer function is given for each circuit
   C) An input & output waveform is sketched for each circuit

3. Without references, the student will define photodetector parameters. Performance will be satisfactory if definitions convey the same meanings as described in the RCA Electro-Optics handbook.

4. Without reference, the student will describe position sensitive detectors. Performance will be satisfactory if:

   A) Descriptions include the following types; quandrant photodiode, image dissecting photomultiplier, silicon position sensor, vidicon, scanning mirror angle tracker
   B) Descriptions include drawings of each type
   C) Terminology is similar to that used in text

5. Given appropriate equipment, the student will measure photodiode responsivity. Performance will be satisfactory if measurements are within 5% of manufacturer's specifications.

6. Given appropriate equipment, the student will determine position-sensitive photodiode linearity. Performance will be satisfactory if linearity is determined to within 5% of manufacturer's specifications.

7. Given job specification sheet, silicon position sensor, and all necessary equipment, the student will construct a height gage. Performance will be satisfactory if thickness of a test piece is measured accurately to within 2% of specified range.

8. Given schematic and necessary materials, the student will construct a laser alighnment system. Performance will be satisfactory if automatic alignment is demonstrated with accuracy of 5% of detector width.

9. Without references, the student will explain photodiode array operation. Performance will be satisfactory if:

A) Block diagram of array is drawn
B) Equivalent circuit is drawn with currents and voltages properly indicated

10. Without references, the student will contrast linear detector arrays. Performance will be satisfactory if essential differences in timing, sensitivity, and temperature dependence among array types are discussed.

11. Given Reticon application note "The Selection of a Line Scan Camera for Industrial Measurement Applications", and a list of system requirements, the student will specify a line scan camera. Performance will be satisfactory if camera selected will meet system requirements.

12. Given a line scan camera with spectral response curve, monochromator, & a colored glass filter, the student will determine filter spectral transmittance. Performance will be satisfactory if results are within 10% of all wavelengths of curve obtained using spectrophotometer.

13. Without references, the student will describe nondestructive testing techniques. Performance will be satisfactory if descriptions include all techniques discussed in the article "A New Look at Inspection" from American Machinist, August 1979.

14. Without references, the student will describe optical measurement techniques. Performance will be satisfactory if descriptions include:

A) Fiber optic technique
B) Scanned laser technique
C) Interferometric techniques
D) Triangulation methods
E) Photodetector array techniques

15. Given a laser, scanner, & necessary optics & electronics, the student will measure rod diameter. Performance will be satisfactory if a test piece is measured to within 2% of its actual diameter.

16. Given surface finish standards and appropriate optical equipment, the student will measure surface roughness. Performance will be satisfactory if roughness is determined to with 10% of standards.

17. Given a roll of paper & a scanned laser or a line scan camera with necessary equipment, the student will detect surface anomalities. Performance will be satisfactory if:

A) Anomality with diameter of 1% of paper width is detected
B) System shows no tendency to trigger with clean paper

18 Given necessary equipment, the student will measure wire diameter using diffraction method. Performance will be satisfactory if measurement is correct to within 2% of micrometer measurement.

19. Without references, the student will describe material processing parameters. Performance will be satisfactory if description includes important parameters of the following:

A) Laser beam characteristics
B) Focusing optics
C) Thermal characteristics of material
D) Reflection & absorption of material

20. Given a laser pulse duration & energy, thermal diffusivity, specific heat & heat of fusion of a metal, the student will calculate weld depth. Performance will be satisfactory if calculation is correct to two significant figures.

21. Given laser properties & focusing apparatus parameters, the student will calculate focal diameter. Performance will be satisfactory if calculation is correct to two significant figures.

22. Given a ruby laser & associated equipment, the student will weld wires. Performance will be satisfactory if weld hold under a 10 lb. tension. 5

23. Given appropriate equipment, the student will construct auto-focus device. Performance will be satisfactory if single-shot penetration of 16 gage steel is demonstrated when used in conjunction with a ruby laser.

24. Given appropriate equipment, the student will collimate a laser diode. Performance will be satisfactory if beam divergence of less than 5 mr in both axes can be demonstrated.

25. Without references, the student will describe waveguide loss mechanisms. Performance will be satisfactory if all of the following mechanisms are listed and described:

A) Material absorption
B) Linear scattering
C) Non-linear scattering

26. Given materials listed in Corning product information guide "Attenuation Measurement Method", the student will measure optical fiber attenuation. Performance will be satisfactory if measurement is within 10% of manufacturer's specifications.

27. Without references, the student will describe waveguide dispersion mechanisms. Performance will be satisfactory if all of the following mechanisms are listed and described:

A) Material dispersion
B) Waveguide dispersion
C) Modal dispersion

28. Without references, the student will describe index profile measurement. Performance will be satisfactory if one of the methods explained in Chapter 4 of Principles of Optical Fiber Measurement by Dietrick Marcuse is thoroughly described.

29. Without references, the student will describe modal noise. Performance will be satisfactory if description includes causes & cures of a modal noise as outlined in the article "Modal Noise-Causes & Cures" from Laser Focus, September, 1981.

30. Without references, the student will describe waveguide bandwidth measurement. Performance will be satisfactory if description includes optical schematic & functions of all components outlined in Corning product information bulletin "Bandwidth Measurement Method".

31. Given materials listed in Corning product information guide "Numerical Aperature Measurement Method", the student will measure numerical aperature. Performance will be satisfactory if measurement is within 10% of manufacturer's specification.

32. Given materials listed in Corning product information guide "Core Diameter Measurement Method", the student will measure waveguide core diameter. Performance will be satisfactory if measurement is within 2% of manufacturer's specification.

33. Without references, the student will describe optical data storage. Performance will be satisfactory if ideas communicated convey the same meaning as described in text.

34. Without references, the student will describe a bit-oriented optical memory. Performance will be satisfactory if description includes block diagram with the following elements: laser, modulator, beam deflectors, optical storage material, detector, electronic control unit, addressing command signal, read-write-erase command signal.

TLO 230

MEASUREMENTS AND HOLOGRAPHY

COURSE SYLLABUS

FALL SEMESTER, 1983

INSTRUCTOR: DAVID TYREE

COURSE DESCRIPTION:

This course includes topics such as dispersion and refraction index measurements with prism/grating spectrometer, use of monochromators and spectrophotometers, use of interferometers, Q-switchgraphic processes, including HNDT, time lapse, time average and multiple exposure. The set-up of holographic systems, processing and analysis techniques will be emphasized.

COURSE REFERENCES:

TEXT: Course X, Laser/Electro-Optic Measurements, Waco: Technical Education Research Center

Tung H. Jeong, A Study Guide on Holography, New York: American Photographic Book Publishing Co.

Suggested:
George Dowbenko, Homegrown Holography, New York: American Photographic Book Publishing Co.

ASSIGNMENT SCHEDULE:

WEEK	ASSIGNMENT
1	Course X, Module 1
2	Course X, Module 2, 3
3	Course X, Module 4
4	Class Hand-outs
5	Course X, Module 6, 7
6	Course X, Module 8
7	Course X, Module 5
8	Midterm
9	Course VII, Module 4
10	Tung H. Jeong, Chap. 6, 7, 8
11	Class Hand-outs
12	Tung H. Jeong, Chap. 1, 2
13	Tung H. Jeong, Appendix
14	Tung H. Jeong, Chap. 3
15	Tung H. Jeong, Chap. 4
16	Finals

LAB SCHEDULE:

WEEK	LAB TITLE
1	No Lab
2	Spectrometers
3	Spectrophotometers
4	Michelson Interferometers
5	Twyman Green & Mach-Zender
6	Modulation Transfer Function
7	Fabry Perot Interferometer
8	No Lab (Midterm Break)
9	Transmission Hologram
10	Reflection Hologram
11	Holographic Interferometry
12	Holographic Defraction
13	Dichromated Gelatin Holograms
14	No Lab (Thanksgiving)
15	Hologram
16	Finals

GRADE EVALUATION

12 Labs at 20 Points each	240
4 Tests at 100 Points each	400
Midterm Exam at 150 Points	150
Final Exam at 200 Points	200
Lab & Test Attendance	10

Total	1000

TLO 160

LASER DEVICES

COURSE SYLLABUS

FALL SEMESTER 1983

INSTRUCTOR: H. J. DEIGL
Office - EB3; Phone - 885-4505

COURSE DESCRIPTION:

Properties and uses of holographic equipment, photographic instrumentation, special purpose imaging devices, laser modulators, Q-switching devices, and the use of laser collimators & autocollimators, spatial filters, beam expanders and Farady isolators. 3 hours lecture, 4 hours laboratory.

COURSE FOCUS:

The main focus of this course will be to use and analyze lasers and other related devices.

COURSE GOALS/OBJECTIVES:

1. Design optical detector
2. Use optical detectors
3. Measure photodetector parameters
4. Rotate polarized light
5. Analyze polarized light
6. Compare birefringent materials
7. Use optical isolators
8. Calculate electric field rotation
9. Calculate Q-switched parameters
10. Use a Q-switch
11. Record laser induced phenomena
12. Describe Q-switching
13. List mode lockers
14. List electro-optical applications
15. Calculate acusto-optical parameters
16. Describe acusto-optical devices
17. Describe the electro-photo characteristics
18. Explain mode locking
19. Explain Farady rotation effects
20. Calculate energy conversions
21. List photographic recording terms
22. Take exam

COURSE REFERENCES:

TEXT: Cord, Laser Electro-Optical Devices, Module 6, Waco: Cord, Inc., 1980

EQUIPMENT LIST: General laser facility and all equipment.

COURSE EVALUATION:

There are 500 possible points in this course. It takes 460 for an A, 410 points for a B, 350 points for a C, and 275 points for a D.

ADDENDUM A
Performance Objectives

1. Given module 7-2 & equipped laboratory, the student will design optical detector. Performance will be satisfactory when Quantum detector in module 7-2 is constructed and working and the thermal detector in module 7-2 is constructed and working.

2. Given a typical laboratory set up, the student will use optical detectors. Performance will be satisfactory when a one milliwatt HeNe laser is measured and a pulsed laser's energy is measured and a standard source is measured.

3. Given laboratory and all equipment needed, the student will measure photodetector parameters. Performance will be satisfactory when all electrical criteria have been met and the detector works and can measure irradiance of given source.

4. Given a low power lab and 1/4 wavelength and 1/2 wavelength plates, the student will rotate polarized light. Performance will be satisfactory when a 1/4 wavelength of rotation is accomplished and a 1/2 wavelength of rotation is accomplished using 1/4 and 1/2 wavelength plates. Rotation will be analyzed by power meter and oscilloscope.

5. Given a general laboratory with three sources, the student will analyze polarized light. Performance will be satisfactory when three light sources have been analyzed: Laser, filtered Hg source and mystery source.

6. Given three birefringent materials and a laboratory setting, the student will compare birefringent materials. Performance will be satisfactory when the comparison of three materials is made to: Composition, ordinary and extraordinary indexes have been identified and the preferred axis of the material identified.

7. Given the Argon laboratory and related equipment, the student will use optical isolators. Performance will be satisfactory when isolation in a ring laser has been accomplished using 1/2 wavelength or 1/4 wavelength plate and Farady rotator.

8. Given a birefringent sample of known length and verdet constant, the student will calculate electric field rotation. Performance will be satisfactory when the degree of rotation is correct to two significant figures.

9. Given the Q-switch lab & related equipment and supplies, the student will calculate Q-switch parameters. Performance will be satisfactory when the parameters for an electro-optical Q-switch have been calculated to two significant figures.

10. Given the ruby GLASS laboratory, the student will use a Q-switch. Performance will be satisfactory when the ruby or Nd&GML.Glass laser has a Q-switched output and is recorded on the storage oscilloscope.

11. Given a laser laboratory and all necessary equipment, the student will record laser induced phenomena. Performance will be satisfactory when the output pulse has been recorded on oscilloscope and the work piece has laser damage and the work piece is analyzed with traveling microscope.

12. Given paper and pencil, the student will describe Q-switching. Performance will be satisfactory when the time history of the flash lamp is explained, loop gain is explained and amplifier gain is explained; the output pulse is consistent with Q-switching.

13. Given paper and pencil, the student will list mode lockers. Performance will be satisfactory when three mode lockers have been listed.

14. Given paper and pencil, the student will list electro-optical applications. Performance will be satisfactory when the light of the ten applications in module 7-9 page 13 have been listed.

15. Given paper & pencil, the student will calculate acusto-optical parameters. Performance will be satisfactory when the Bragg angle for a quartz acusto-optical device has been calculated and the frequency of the modulator to obtain 5% diffléction.

16. Given paper and pencil, the student will describe acusto-optic devices. Performance will be satisfactory when Bragg diffraction is explained, acusto-optical mode locking is explained, acusto-optical modulation is explained and acusto-optical cavity dumping is explained.

17. Given paper and pencil, the student will describe photo-detector characteristics. Performance will be satisfactory when the following list is described: Photodectector, photoconductivity, photo emissive, photo voltaic, responsivity, spectral response time, quantum efficiency, shot noise and Johnson noise.

18. Given paper and pencil, the student will explain mode locking. Performance will be satisfactory when the explanation is consistent with module 7-11, page 23.

19. Given paper & pencil, the student will explain Farady rotation effects. Performance will be satisfactory when the design and operation of the optical isolator is consistent with the text.

20. Given paper and pencil, the student will list photographic recording terms. Performance will be satisfactory when 13 of the 15 terms listed on page 17 of module 7-3 have been accomplished.

21. Given an energy chart and pencil, the student will calculate energy conversions. Performance will be satisfactory when the energy chart can be filled in.

22. Without reference, the student will take exams. Performance will be translated into points & answers must be consistent with course document.

TLO 250

VACUUM SYSTEMS & OPTICAL FABRICATION

COURSE SYLLABUS

FALL SEMESTER, 1983

INSTRUCTOR: DAVID TYREE
Office EB3; Phone 885-4180

COURSE DESCRIPTION:

The theory and practices of glass grinding, testing, and thin film depositions. Theory of low pressure tube devices. The application and maintenance of vacuum systems. This class will emphasize hands-on experience with different laboratory equipment. 3 hours lecture, 4 hours laboratory.

COURSE GOALS/OBJECTIVES:

This course will address the following goals:
Performance Objectives may be found in Addendum A.

1. Convert millitor to millimeters of mercury
2. List steps for vacuum pumping
3. Describe Denton DV-502 control panel
4. Describe Boyle's law
5. Perform pumps down procedure
6. Compare static to dynamic vacuum systems
7. Describe the mechanical pump
8. Describe the diffusion pump
9. Clean the vacuum system
10. Inspect pump oil
11. Calculate pumping speed
12. Calculate pump down time
13. Design a vacuum system
14. Describe the cold cathode ionization gauge
15. Diagram high vacuum pumps
16. Describe vacuum gauges
17. Apply coatings
18. Test coatings
19. Describe cold trap operation
20. Calculate evaporation temperatures
21. Calculate evaporation currents
22. Determine coating materials
23. Define deposition systems
24. Set up sputtering lab
25. Determine leak rate
26. Construct a work stand
27. Outline shaping procedure
28. Determine focal lengths
29. Shape a work piece
30. Perform newtonian interferometry test
31. Outline grinding procedure
32. Test surface finish
33. Grind a work piece
34. Outline polishing procedure
35. Construct a pitch lap
36. Polish a work piece
37. Explain figure testing procedure
38. Perform Foucault's knife edge test
39. Perform figure correction
40. Coat the work piece

COURSE REFERENCES:

TEXT: Guthrie, Andrew, Vacuum Technology, New York:
John Wiley & Sons, Inc., 1964 Edition

COURSE EVALUATION:

There are 400 possible points in this course. It takes 373 points for an A, 340 points for a B, 300 points for a C, and 267 points for a D.

ADDENDUM A
Performance Objectives

1. Given a blank sheet of paper, the student will convert millitor to millimeters of mercury. Performance will be satisfactory if proper conversion of altitude as well as vacuum pressures are shown.

2. Given a Denton DV-502 vacuum system and manual, the student will list steps for vacuum pumping. Performance will be satisfactory if an instructor observes the proper steps in their proper order.

3. Given a Denton DV-502 vacuum system and manual, the student will describe the control panel. Performance will be satisfactory if each switch, knob, dial, and meter is defined as to what equipment it controls.

4. Given a blank sheet of paper, the student will describe Boyle's law. Performance will be satisfactory if the relationship between temperature, pressure, and volume in relation to such vacuum terms as "outgassing", "pumping speed", and "blank off pressure" are clearly defined.

5. Given a Denton DV-502 vacuum system and manual, the student will perform pump down procedure. Performance will be satisfactory if the system is pumped down to a maximum pressure of 5×10^{-5} torr.

6. Given a blank sheet of paper, the student will compare static to dynamic vacuum systems. Performance will be satisfactory if the advantages & disadvantages of each system as listed in the text are explained.

7. Given a Denton DV-502 vacuum system and manual, the student will describe the mechanical pump. Performance will be satisfactory if the description given conforms to that given in the text.

8. Given a Denton DV-502 vacuum system and manual, the student will describe the diffusion pump operation. Performance will be satisfactory if the description given conforms to that given in the text.

9. Given a Denton DV-502 vacuum system, tool kit, lint free towels, methanol, high vacuum grease & pumice, the student will clean the vacuum system. Performance will be satisfactory if the system will pump down to a maximum pressure of 5×10^{-5} torr.

10. Given a Denton DV-502 vacuum system and manual, the student will inspect pump oil. Performance will be satisfac-

tory if proper procedure, as outlined in the text, is followed.

11. Given volume and pumping speed, the student will calculate pump down time. Performance will be satisfactory if calculations are the same as those found by the instructor.

12. Given the vacuum chamber volume, sizes of connecting lines, & pump down time required, the student will design a vacuum system. Performance will be satisfactory if calculations match those found by the instructor.

3. Given a Denton DV-502 vacuum system & manual, the student will describe the cold cathode ion gauge operation. Performance will be satisfactory if the description conforms to that given in the text.

14. Given a blank sheet of paper, the student will diagram high vacuum systems. The performance will be satisfactory if the advantages and disadvantages of each system, as listed in the text, are explained.

15. Given a blank sheet of paper, the student will describe vacuum gauges. Performance will be satisfactory if all gauges listed in the test are listed and described.

16. Given a Denton DV-502 vacuum system, HeNe laser, power meter, strip chart recorder, microscope slides & magnesium flouride, the student will apply an A.R. coating. Performance will be satisfactory if the A.R. coating is shown to reduce reflectance.

17. Given optics, and an HeNe laser, the student will test coatings. Performance will be satisfactory if the student can measure reflected or transmitted power to determine the percent of transmission or reflectance.

18. Given a Denton DV-502 vacuum system & manual, the student will describe the cold trap operation. Performance will be satisfactory if the description given conforms to that given in the text.

19. Given a nomograph & coating material, the student will calculate evaporation temperature. Performance will be satisfactory if the calculations match those given by the instructor.

20. Given a nomograph, wire diameter, and evaporation temperature, the student will calculate evaporation current. Performance will be satisfactory if calculations match those found by the instructor.

21. Given a coating material, & volume of vacuum chamber, the student will determine coating material amount. Perfor-

mance will be satisfactory if figures match those provided by the instructor.

22. Given a blank sheet of paper, the student will define deposition systems. Performance will be satisfactory if all the procedures listed in the deposition handout are listed in their proper order and defined.

23. Given a DV-502 vacuum system, wire cathode, & microscope slides, the student will set up a sputtering lab. Performance will be satisfactory if a smooth even coating of a reasonable thickness is deposited on a substrate.

24. Given a DV-502 vacuum system, needle valve, & vacuum gauge, the student will determine leak rates. Performance will be satisfactory if a graph showing pressures in relation to time is drawn.

25. Given concrete blocks, scrap wood & plexiglass, the student will construct a work stand. Performance will be satisfactory if the work stand offers freedom of movement for a worker, absence of movement for the work piece, and is of proper height and size for grinding.

26. Given a blank sheet of paper, the student will outline shaping procedure. Performance will be satisfactory if all procedures listed in the text are listed & explained.

27. Given a spherometer & spherical mirror, the student will determine the focal length. Performance will be satisfactory if figures match those of the instructor.

28. Given a work bench, tool, work piece & grinding compound, the student will shape a work piece. Performance will be satisfactory if proper focal length is shown.

29. Given a work piece, master flat, and monochromatic light source, the student will perform newtonion interferometry test. Performance will be satisfactory if radius of curvature matches that found by the instructor.

30. Given a blank sheet of paper, the student will outline grinding procedure. Performance will be satisfactory if all procedures listed in the text are listed and explained.

31. Given a work piece, and magnifying glass, the student will test the surface finish. Performance will be satisfactory if the surface finish conforms to that listed in the text.

32. Given a workstand, tool, work piece & grinding compounds, the student will grind a work piece. Performance will be satisfactory if proper focal length and surface finish is shown to exist.

33. Given a blank sheet of paper, the student will outline polishing procedure. Performance will be satisfactory if all procedures listed in the text are listed & explained.

34. Given an electric heater, pitch, tool & work piece, the student will construct a pitch lap. Performance will be satisfactory if the curvature & surface design match that required by the work piece.

35. Given a pitch lap, workstand, tool, work piece & rouge, the student will polish a work piece. Performance will be satisfactory if the surface finish conforms to that listed in the text.

36. Given a blank sheet of paper, the student will explain figure testing. Performance will be satisfactory if all procedures listed in the text are listed and explained.

37. Given an illuminated pinhole sized source, knife edge, & spherical mirror, the student will perform Foucault's knife edge test.

38. Given a glass substrate, work stand & pitch lap, the student will perform figure correction. Performance will be satisfactory if the Foucault knife edge test shows proper curvature of the surface.

39. Given a DV-502 vacuum system, a polished mirror substrate, and aluminum wire, the student will coat the work piece. Performance will be satisfactory if a smooth, even coating of a reasonable thickness is deposited on the mirror.

Equipment

The following is a listing of the labs and the equipment contained in each laboratory.

A partial list of equipment purchased since the program's inception and justifications for purchases also follow. (Equipment purchased during the 1976-1977 academic year is not included.)

First Year Laser Lab

Dimensions: 20' x 40', divided into 8 curtained booths
Number of Students per Lab: 12 - 16, 2 per booth

High Power CO_2 Laser Lab

Dimensions: 12' x 18'
Equipment: 18MW Pulsed CO_2 - Lumonix Kit
30W CW CO_2 - student built
40KV at 20ma power supply - Del Electronics

Number of Students per Lab: 2 - 3

Microprocessor Lab

Dimensions: 6' x 9'
Number of Students per Lab: 2
Equipment: Intel's "Intellec 8" w/TTY (8008 cwp)
(a classic antique, but functional)
Rockwells "AIM 65" w/printer (6502 cwp)

Holography Lab

Dimensions: 12' x 20'
Number of Students per Lab: 3 - 5
Equipment: 4' x 8' concrete table w/isolation
CR-2 Krypton laser 1.5w all lines
Coherent radiation 7mu He-Ne

Glass Blowing & Optical Fab Shop

Dimensions: 9' x 30'
Number of Students per Lab: 5 - 8
Types of Labs: Spring Semester - Glass Blowing Techniques
Fall Semester - Optical Grinding & Polishing

1) Telescope Reflector
2) Optical Flats

Pulsed Nd:Glass, Ruby, & CW Nd:Glass, Ruby, & CW Nd:YAG Lab

Dimensions: 9' x 18'
Number of Students per Lab: 2 - 3
Equipment:

1.5W CW	
Nd:YAG at 1.06 Micromicrons 100 MW CW Nd:YAG at 532nm (with frequency doubler)	General Photonics
Pulsed Nd:Glass & Ruby System (interchangeable rods) Ruby: 7 joules - 30KW at 6943A Nd:Glass: 12 joules - unswitched 1 joule - 10MW Q - switched	Apollo Lasers

Argon Laser Lab

Dimensions: 9' x 18'
Number of Students per Lab: 2 - 3
Equipment : CR-2 Argon laser - 3W all lines

Vacuum Lab

Dimensions: 9' x 8'
Number of Students per Lab: 3 - 5
Equipment: DV-502 vacuum system - Denton vacuum
Circulator-chiller - Neslab
Types of Labs:
1) Operating procedures
2) High vacuum attainment
3) A-R coatings
4) Thin film deposition
5) Carbon evaporation

Electronics Lab-Lecture Room

Number of Students per Class: 24

The Electronics Department at Vincennes University has just recently changed over to a new teaching system which incorporates both lecture and lab into one four-hour period, 3 days per week.

ITEM (MAKE AND MODEL) OR EQUIVALENT	UNIT COST	QTY	TOTAL COST
Laser LSR7 HeNe 7mw	$ 865.00	1	$ 865.00
Laser LSR5 HeNe 5mw	455.00	1	455.00
Base Plates for Above Lasers	16.00	2	32.00
Photomultiplier Power Supply #7026	645.00	1	645.00
Star Gimbal Mount SG-101	145.00	2	290.00
Optical Power Meter .1mw to 1w UDT-40-X	545.00	4	2180.00
Beam Expander/Collimator F-100mm 25mm 280-25	1000.00	1	1000.00
Laser HeNe 2mw TEMoo #132	238.00	5	1190.00
Spectroscope - grating type S75903-72	106.25	2	212.50
Laser Line Filter G-525-6328	98.00	1	98.00
Laser Line Filter G-524-10601	130.00	1	130.00
Interference Filter Set 03 FIB 015 (set of 7)	445.00	1	445.00
Translation Stage 20.125	215.00	4	860.00
Optical Power Meter .02-100mw 450B	350.00	2	700.00
Rotable Object Holder L363A	174.00	2	348.00
Wollaston Prism 16mm aperture L363Q	195.00	2	390.00
Optical Flat #1611	145.00	4	580.00
Microscope, including the following:			
Viewing Microscope 22-9153	251.00	2	502.00
Mic Obj 83m 25-0076	29.00	2	58.00
Michelson Interferometer 25-9069	673.00	1	673.00
X-Y Translation State 90m, including:			
Transverse Motion	58.00	6	348.00
Vertical Motion	54.00	4	216.00
Lateral Displacement Units	19.75	2	39.50
Rotating Tables, including:			
Table 227900	17.00	2	34.00
Graduated Rotating Table	132.00	2	264.00
Hold-down Clamps 2279670	42.75	2	85.50
Optical Benches, including:			
Steel Tri Optical Bench 2m	369.00	2	738.00
Set of Two Leveling Crossfeet	38.50	2	77.00
Lens Holders, including:			
Self-Centering Lens Holders	125.00	4	500.00
10 CM Slide Grip Lens Holders	35.50	4	142.00
Screen Holder	30.50	2	61.00
Multiple Lens Holder	240.00	1	240.00
Centering Point	8.90	2	17.80
Storage Rack	17.75	1	17.75
Carriers, including:			
Tri Carrier 90mm	19.00	6	114.00
Short Pillar	11.00	2	22.00
Tri Carrier 65mm	17.50	2	35.00
Pillar	11.50	4	46.00
Height Setting Collars	9.50	6	57.00

ITEM (MAKE AND MODEL) OR EQUIVALENT	UNIT PRICE	QTY	TOTAL COST
Carriers (continued)			
Pin Mount & Tilt Device	23.15	2	46.30
Precision Pinhole Set	208.00	1	208.00
Accousto-Optic Modulator DLM-IV	1500.00	1	1500.00
Electro-Optic Modulator 1000/1 001	475.00	1	475.00
Filters, Color, Set of 17, 3-1/8" Molded	118.00	2	236.00
Mercury Arc Light Source 87268	175.00	2	350.00
Power Supply 87335	170.00	2	340.00
AC-3 Pinhold Autocollimator	945.00	1	945.00
In-Line Wattmeter 0-10W #43 & Elements	132.00	3	396.00
Optic Benches 60-210	35.00	4	140.00
Gimballed Component Mount	45.00	8	360.00
Adjusting Laser Carriers	25.00	4	100.00
Mounting Pins 13.7	17.00	16	112.00
Pin Carriers 60mm	12.00	16	192.00
Laser HeNe 2mw TEMoo Modulated 50-500 KHZ	295.00	2	590.00
18" x 18" Polarizing Sheet and Filter	23.00	1	23.00
Prism Bins Set	30.00	2	60.00
Tygon Tubing, 100'	71.83	1	71.83
Rubber Tubing, 50'	44.00	1	44.00
Pulsed Energy Meter	1450.00	1	1450.00
Prism Set, including: 1 Poro, 2 Wedge, 1 Dove, 2 Equilateral, 2 Right Angle	307.00	1	307.00
Gimballed Mirror Mounts	215.00	2	430.00
Adapters for Gimballed Mirror Mounts	50.00	2	100.00
Spatial Filter, 10 Pinhole	378.00	1	378.00
Meter Rails	105.00	4	420.00
Crosslegs (sets) for Meter Rails	33.50	4	134.00
Scissor Jacks	204.84	1	204.84
USAF Target 50mm x 5m Negative-Emulsion 70.6045	35.98	1	35.98
Total			$24,357.00

1.	2	X-Y Plotters (Heath-Schemberjet) at $500.00	$ 1,000.00
2.	16	Photo Diodes (U.D.T.) at $15.00	240.00
3.	1	Accelerometer: ENDEVCO #2215E	1,200.00
4.	2	Motorized Translation Stage at $600.00 (Items 1-4 are needed due to increased enrollment)	1,200.00
5.	2	Tektronix 3-Hole Mainframe at $175.00	350.00
	2	P/S Text #503A at $300.00	600.00
	2	Generator #F-5-503 at $400.00	800.00
	2	DVM #502 at $350.00 (These items will be utilized in every laboratory throught the two year program)	700.00
6.	1	Yag-Two Laser (This laser will enable us to make more efficient use of existing instructional lasers and laser systems in the department to date.)	1,400.00
7.	2	Vacuum pumps (roughing) at $650.00 (Needed because of increased number of students in Fabrications.)	1,300.00
8.	2	National beam splitters, 2" diameter, at $325.00	650.00
9.	4	First surface concave and convex 1 meter focal irrors at $200.00	800.00
10.	12	5cm diameter, 5cm focal length at $63.00	756.00
11.	2	Optical Beam Splitters at $213.00 (Theoretical operation of this equipment is taught in class, and it is needed for practical applications and experiences.)	426.00
12.	2	I-R Screens (Infrared) at $30.00 (Needed for detection of infrared radiaiton.)	60.00
		Total	$11,482.00

1.	1	Frequency Doubler For Existing Laser	$ 3,000.00
2.		Custom Made Cold and Hot Cathode HeNe Plasma Supplies: Including	
		2 Tubes at $175.00	350.00
		2 Power Supplies at $150.00	300.00
3.	1	Assortment Holographic Timing and Technical Related Equipment	800.00
4.	1	Assortment Component Support Hardware, Including X or Y or Z Translators; X-Y Translators; X-Y-Z Translators; Pin Carriers; Rails; Etc.	800.00
5.	1	Assortment Special Reflecting and Refracting Optics for Infrared Lasers for Applications	800.00
6.	1	Isolation System for Holography Course	800.00
		(Items 1-6 are needed for upgrading and because of increased enrollment.)	
7.	3	Optical Power Meters at $1200.00	3,600.00
8.	3	HeNe Lasers at $475.00	1,425.00
9.	3	Adjustable Slits at $100.00	300.00
10.	3	Translation Stages at $300.00	900.00
11.	3	Graduated Rotating Tables at $190.00	570.00
12.	4	Prism/Grating Spectormeters at $1500.00	6,000.00
13.	3	Polarizer/Analyzer at $350.00	1,050.00
14.	3	Transmission Gratings at $25.00	75.00
15.	3	Reflection Gratings at $100.00	300.00
16.	6	Self-Centering Lens Holders at $130.00	780.00
17.	6	Base with Standard Pillar at $30.00	180.00
18.	3	1 m Optical Rail at $120.00	360.00
19.	3	1/4m Optical Rail at $40.00	120.00

(At the present time we have enough equipment for two lab stations for most experiments in our Laser Physics classes. Often students are expected to work four at a station which allows eight students per lab. Obviously four students per station does not allow the meeker student to get the necessary "hands-on" experience and the feeling of involvement that is educationally desirable. When using expensive equipment of which we have only one piece--such as the spectrometer--students are currently scheduled during the lab period to an allotted amount of time in which to use the apparatus and collect data. Large numbers of students using one piece of equipment leads to a hurried use and degrades the results.

Two students per lab station would be ideal but not financially feasable. Three students per station and five stations would be a good compromise. Items 7-19 would make this possible.)

20.	2	Motorized Translation Stages at $700.00	1,400.00
21.	2	Strip Chart Recorders at $500.00 (Students presently obtain intensity distribution patterms by manually moving a micrometer in fractional steps and taking 50 or more data points. The data must then be graphed. After this very time consuming process, the real purpose of the experiment, analysis of the patterms, may begin. The time required for this allows only one or two patterms to be analyzed. The new equipment would allow several patterms to be scanned and compared.)	1,000.00
22.	6	Fiber Optic Probes at $150.00 (At the present time we make our own fiber probes. As a result of not having the proper equipment for splicing, positioning, etc., the probes have high losses, poor coupling, and cannot make sensitive reading. The commercial probes would allow students to take reading in the low intensity portions of the distributions, which is where the critical measurements need to be made.)	900.00
23.	1	Travelling Microscope (The microscope we are now using has very worn gears. As a result, measurements are only approximate, which defeats the purpose of a travelling microscope. It is used for precise measurements of slit widths, circular diameters, and thicknesses.)	1,200.00
		Total	$27,010.00

1.	1	DV-502 Vacuum System with E-Gun Etcher and Extra High Volume Roughing Pump (Currently there is only one vacuum system in the Laser department. As a result, the number of students allowed in a scheduled lab cannot exceed four students. With the enrollment in this class projected to be no less than 25 next year, the number of lab contact hours for the lab alone will probably run as high as 20-25 hours, excluding lecture and other classes. This system, along with item 6, will allow up to 12 students per lab. The diversification of the equipment will allow the instructors to have more labs pertaining to Vacuum Systems and Thin Film Deposition, with a reasonable number of lab contact hours per week.)	$ 8,500.00
2.	1	Model 5 Apollos Pulsed Ruby System (We presently have only one pulsed system in the entire two year program. Industry, research, and development all employ and used pulsed lasers extensively. An additional pulsed system can be used in all courses except the two offered in the first semester. Also, the existing system is down for repair approximately 50% of the time, and labs pertaining to pulsed lasers are either cancelled or rescheduled, causing a multitude of internal lab problems.)	12,000.00
3.	2	Temperature Controlled Circulators RTE-8 at $1,150.00 (The pulsed laser has many experiments where the data collected involves temperature changes. If item number 2 is approved, this equipment will give much flexibility to temperature controlled circulators. Also, vacuum systems must have cold water or Liquid Nitrogen circulating through the cold trap to get and maintain high vacuums. Items number 1 and number 6 must have refrigeration or cooled circulators for proper operation.)	2,300.00

4.	1	Apollo Calorimeter (The Calorimeter provides the only means of measuring the energy from a pulsed laser. Without any means of detecting pulsed laser energy, calculations for the applications, measurements, holography, and pulsed laser classes will not be possible. Theoretical and experimental results cannot be compared and studied.)	1,200.00
5.	1	High Voltage Power Supply 40Kv at 50ma (A majority of the department's lasers depend on high voltage power supplies. Many of the projects where lasers are designed and built require this type of power supply. This one supply will have capabilities of powering any of the high voltage lasers in the department now, or any bought or built in the future.)	1,800.00
6.	1	Dual-Gas Fill Station with Assorted Hardware (Since the state began paying lab fees for all classes in the department, there are a number of classes where laser tubes must be sent away for recharging or initial charging, with the average price for one fill or recharge being $125.00. No less that 15 fills per year are required, and with enrollment continually increasing, this will be money well spent.)	1,200.00
7.	1	Power Meter - Coherent model 210 11kw (Our four high powered lasers are now monitored by a single power meter. The existing meter cannot measure powers above 10 watts. This model 210 will allow us to extend the range by a factor of 3 and measure output powers of two more lasers.)	500.00

Total			$27,500.00

1.	2	Sodium Sources at $450.00	$ 900.00
2.	2	Mercury Sources at $125.00 (Optical sources are required in all classes, and we presently must use the Physics Department sources, which is inconvenient for both areas.)	250.00
3.	3	Universal Interferometer/Accessories, Extra Mounts for Tilting, Rotating Plates and Angular Adjustments (We lack good equipment for the basic measurements portion of labs which are sun in all classes. This equipment will allow higher numbers in the measurements portion of TLO 230.)	3,600.00
4.	3	Three-Hole Mainframes at $300.00	900.00
5.	3	DVM's at $330.00	990.00
6.	6	Power Supplies at $575.00 (With the electronics department growing at such a fast rate, the equipment that was once shared by both departments must be used only by electronics students. This necessitates purchase of equipment which can be used independently.)	3,40.00
7.	2	5000-Series Scopes at $2,000.00 (See rationale for number 3, please.)	4,000.00
8.	3	Sets HeNe Optics for 45cm. Tubes at $237.00 (We presently have three HeNe plasma tubes with optical mirror requirements which we cannot meet.)	711.00
9.	2	15mw HeNe polarized 1000:1 at $4,300.00	8,600.00
10.	5	4-Inch First Surface Mirrors at $136.00	680.00
11.	2	50/50 Beam Splitters at $170.00	340.00
12.	3	Variable Beam Splitters at $600.00	1,800.00
13.	2	Spatial Filters/10, 25, & 50 Micron Pinholes at $400	800.00
14.	2	Isolation Tables 3' x 6' x 8" NRC type at $2,188.00	4,376.00
15.	2	Sets Isolation Legs; 3 Legs Each at $1,000.00	2,000.00
		Total	$33,397.00

1.	4	HeNe Power Supplies at $325.00 (Lab exercises require the matching of a laser tube with a power supply.)	$ 1,300.00
2.	1	CO_2 Power Supply	1,500.00
3.	1	Argon Laser Tube (Needed as a replacement.)	7,500.00
4.	3	Optical Power Meters at $400.00 (These will cover most general purpose lab requirements, and are relatively inexpensive.)	1,200.00
5.	1	Scanner Driver (These will be used for instruction in numerous laser applications, such as automatic gauging and inspection, and bar code readers.)	1,300.00
6.	2	HeNe Lasers at $605.00 (These are needed in all classes. Some of the lasers which have had heavy use for six years are malfunctioning and need to be replaced.)	1,210.00
7.	3	Variable Power Supplies HP6235A at $285 (The department has received donations of several injection laser diodes, but we have no suitable power supplies which will render these useful for instruction.)	855.00
8.	12	Laser Safety Goggles at $50.00 (These goggles are suitable eye protection to insure students safe operation of lasers.)	600.00
9.		Set Assorted Lab Equipment, Including:	
	4	Lab Jacks at $80.00	320.00
	10	Magnetic Base Rods at $15.00	150.00
	6	Optical Rails at $250.00	1,500.00
	6	Polarizers at $93.99	558.00
		Assorted Prisms and Lenses	400.00
		Optical Bench Components (Needed to provide instruction for higher enrollments in components classes.)	800.00
10.	1	AIM 65 Microprocessor (Needed because of increased enrollment.)	900.00
11.	3	Motorized Translators with Controller at $1167.00	3,501.00
12.	2	Mercury ARC Lamps at $325.00	650.00
13.	1	Laser Alignment System (These are needed in TLO 130 and 140 labs.)	1,500.00

14.	2	High Voltage Power Supplies at $820.00 (High voltage power supplies are required for all the instructional devices used in TLO 160, and all second year classes.)	1,640.00
15.	1	Apple Microcomputer System (Needed for instruction in interfacing microcomputers with lasers and electro-optics.)	6,000.00
16.	1	YAG Laser (Will be used for instructional purposes in TLO 160, 230, 280, and 290, in conjunction with general lab experiments.)	5,800.00
17.	2	NRC Isolation Tables with Components at $10,000	20,000.00
		Total	$59,184.00

1.	1	500 Series Scope	$ 4,200.00
2.	1	Vertical Amplifier 5A48	950.00
3.	1	Sweep Time Base 5B40 (Items 1-3 are needed for use in all classes. Electronic equipment receives continuous use during introductory courses and instruction on laser devices, fabrication, and application.)	700.00
4.	2	2215 Scope at $1400.00 (Needed in all classes)	2,800.00
5.	2	Variable High Voltage Power Supply D.C. at $800.00 (Needed for laboratory assignments which require changing voltages for experimentation.)	1,600.00
6.	1	Argon Replacement Tube with Elalon (Needed for five courses ranging from introductory to application and as a replacement because it is too costly for maintenance and repair.)	9,000.00
7.	1	Helium Leak Detector Bell Jar Evaporator E-Beam (Needed to update courses being taught to consolidate enrollment in fewer labs.)	8,000.00
8.	1	Unimate Lathe (Needed for use in courses to fabricate mechanical components. Allows faculty to make test fixtures and jugs used for special experiments.)	1,200.00
9.	1	Thickness Coating Monitor (Needed for accurate coatings in vacuum deposition laboratory. This is used the entire semester for instruction in fabrication and vacuum systems.)	3,600.00
10.	1	Power Supply for Model 5 Ruby Laser Head 6kV	5,000.00
11.	1	RTE-4 Coller Heat Exchanger for Power Supply for Ruby Laser	1,500.00
12.	1	Replacement Lamp for Ruby Head (These items will allow larger sections for labs as well as enhance the departments' pulsed systems. This equipment is used as the primary laser in special project courses as well as in introductory Fabrication, and application courses.)	800.00

13.	1	Departmental Computer to Include: Dual Floppy Drives, Analog I/O Board, Compiler, Printer, Software (Will be incorporated in our laboratory experiments. The use of microcomputers is common in the laser industry and will update course content.)	6,500.00
14.	1	3 Hole Main Frame	350.00
15.	1	Power Supply Lamp	625.00
16.	1	Frequency Generator	600.00
17.	1	Ramp Generator (Items 14-17 are needed for use in all courses to increase flexibility in labs and provide a more versatile carrier. This equipment would eliminate borrowing from the Electronics Department, where the equipment receives constant use.)	600.00
18.	1	Light Chopper DC to 10 MHz (This piece of equipment will be used in all classes where a simulated pulse is required. Presently we have nothing to use in this capacity.)	2,100.00
19.	3	Steel Matrix Top Tables NRC XS-4 4'x 8' at $2,100.00 (Needed to improve the quality of 3 isolation tables. This improvement would make their quality comparable to other concrete isolation tables used in the department.)	6,300.00
20.	2	HeNe Lasers 5mw polarized at $650.00 (Needed for use in labs and to help relieve the shortage of such lasers throughout the department.)	1,3000.00
		Total	$57,725.00

Faculty

The backgrounds of the faculty members who teach the courses in this program are in Laser Optics and Electronics. All have attained a miminum of an Associates Degree in this area. Some of the faculty have B.S. Degrees in a related field, i.e., Physics, Electrical Engineering, Computer Science, etc. Industrial experience is a must for teaching at Vincennes University.

Placement

The following are examples of companies who have hired graduates from the LEOT program.

Sandia Laboratory Albuquerque, New Mexico
Bell Labs Homdale, New Jersey
Hughes Aircraft Culver City, California
Potter Brumfield Princeton, Indiana
International Laser Systems Orlando, Florida
Ford Corp. Dearborn, Michigan
McDonnell Douglas St. Louis, Missouri
Exxon Corportation New York, New York
Corning Corporation Corning, New York
Texas Instruments Dallas, Texas
Los Alamos Labs Los Alamos, New Mexico
U.S. Steel Corporation Gary, Indiana
The Timken Company Canton, Ohio
IBM Corporation San Jose, California
Xerox Corporation Rochester, New York
Zenith Radio Corporation Elk Grove Vlg., Illinois
Cobilt Division Santa Clara, California
Harris Corporation Melbourne, Florida

Telecommunications and Fiber Optics

Telecommunications is a broad concept. It includes the application of high technology to telephones, television and radio. Telecommunications are simply data networks such as satellites, digitally-encoded telephones and telecopy devices, optical fibers and cables, electronic mail and shopping services, text editing and distribution systems.

It has been forecast that in the near future billions of intercommunication connections will exist to connect industry, home and the office. They will serve a vast array of information processing devices which transmit information in many formats such as stored voice patterns and video images.

To achieve this, optical fiber cabling must first replace copper cabling, thus providing superior transmission. These fiber optic cables are composed of glass fibers surrounded by dielectric buffers. They transmit optical instead of electrical signals. This dielectric material offers significant advantages over metallic systems, such as immunity to lightning and big voltages. The transmitted signals are not destroyed by high voltage, electronic magnetic or radio frequency interference. Fiber optic cables are smaller in diameter than conventional coaxial cables yet have the same signal carrying capacity. They are light in weight, thereby providing ease of installation. Less duct space is required and heavy cable support equipment is eliminated. The longer cable requires fewer repeaters and high signal bandwidths allowing increased channel capacity.

Optical signals do not require grounding connections. Therefore, the transmitter and receiver are electrically isolated. Advantages to this type of system include safety from sparks and shocks, increased reliability due to lack of terminal-to-terminal ground potential shifts, and safe operation in hazardous or flammable environments.

These cables can handle 432 million bits of information per second or over 100,000 two-way conversations at the same time. They are thus a more effective and efficient means for transmitting communication.

Where can you find these new communication systems? With these systems, computers are talking to each other over telephone lines. Cable television uses these systems. The communication lines also have the capability to take instructions from microcomputers, allowing grocery ordering and bank transfers from home. A student can take a test or register for courses from home via microcomputer which is communicating directly with the computer at the registrar's office. The delivery of instruction by telecommunications links will also drastically change the cost and methods of delivering instruction. No longer will the student need to come to the teacher for instruction but instead, the student can go to the interactive video tape on a home television, listen to the lecture and take a test at the conclusion of the lesson.

Telecommunications Technicians will be installing, testing, repairing, monitoring, servicing, modifying and helping to design these complex telecommnications equipment, components and accessories. The systems will no longer consist of parts that need to be assembled but instead will depend on computer operated design, production and repair. The new systems use electronic switching systems (EES) which are programmed to fit each office. EES is also programmed to monitor its own performance and diagnose its own circuitry problems. Therefore, students who want to become telecommunications technicians need computer experience, programming skills and knowledge of electronic operations, lasers and fiber optics.

References

Belden Coporation *Fiber Optic System Design Guide* 1983

Frye, John The Impact of Telecommunications *Technological Horizons in Education Journal* Vol 10 (6) April 1983 pp.87-90

Rodenstein, Judith Emerging careers: The Consequences of High Technology in *Microcomputers: Applications in Vocational Education* Edited by Rodenstein, J. and Lambert, R. Madison, Wisconsin: University of Wisconsin 1983

NAME OF PROGRAM: Telephone Communication Technology
INSTITUTION: Alabama Technical College
1001 E. Broad Street
East Gadsden, Alabama 35999
(205) 547-5451
CONTACT PERSON: Bryan Stone or Larry Lee
DATE PROGRAM STARTED ADMITTING STUDENTS: 1975
DEGREE/CERTIFICATION: Either a one-year diploma course or a two-year Associate Degree program

History of the Program

The college was first contacted by Mrs. Jean S. Brandli, President of coosa Valley Telephone Company in the summer of 1975. Mrs. Brandli was also president of an independent telphone company association. She told the college the association believed there was an urgent need for trained telecommunications personnel not only in Alabama, but in the entire country. The shortage, she believed, was likely to become critical as more and more interconnect companies were formed as a result of an FCC ruling adverse to the AT&T semi-monopoly on telephone systems.

After several meetings with the independent telephone company association, a decision was made to try a training program, provided that the association would:

- assist the school in finding and hiring a qualified instructor,
- assist in curriculum development, and
- provide equipment to initially start the course.

The independent telephone companies responded to the request for equipment by furnishing enough equipment for a laboratory with 20 work stations, a small dial central exchange which produced dial tones, switching capabilities and telephone access equivalent to that which a small city would have.

Advisory Committee

The advisory committee continued to be the independent telephone company association which originally assisted with the creation of the program.

Structure of the Program

The Associate Degree program is a two-year program, four quarters each year. The Diploma program lasts for only one year (four quarters)

Type of Student

As of December 15, 1980, there were 86 full-time students in the program and 26 half-time students in the evening school. As of the Fall Quarter 1983, there were 73 full-time students and 33 half-time students in the evening program. The program is not only providing training for new entries into the job market but also the retraining and upgrading of skills for people currently employed in the telephone industry. Retraining is also provided on an individual basis for those who wish to improve their skills. The retraining of people who have been displaced from their job due to technology are also being retrained. The program coordinator has found that those who enter the program with previous skills in electronics or telecommunications, are not always in need of a diploma or degree. They are concerned primarily with building on the skills which they already have so that they may re-enter the field. These individuals do not complete the entire program but just selected courses. These people, on a case by case basis, are entered into an accelerated program so they may utilize their time and energy to accomplish the goal of re-employment as soon as possible. A Certificate of Completion is issued when they complete their training.

Program Purpose and Objectives

Purpose: The telecommunications program will provide training for aspiring telephone craftspersons to enable them to be employed by a telephone company.

Objectives:

1. To teach the skills which will enable students to be employed as telephone repairers/installers, PBX installers/repairers or central office equipment operators
2. To teach complementary related skills in mathematics and electronics which are essential to obtaining employment
3. To teach the importance of customer relations
4. To promote safe working habits

Associate in Applied Technology Degree

Freshman Year

First Quarter	Lec	Lab	Cr
Electronics 111	5	0	5
Electronics 161	0	10	3
Math 001	5	0	0
Physics 111	5	0	5
Business Education 101	0	5	2
	--	--	--
	15	15	15

Second Quarter	Lec	Lab	Cr
Electronics 122	5	0	5
Electronics 172	0	10	3
Telecommunications 111	0	5	1
Telecommunications 161	0	5	2
Math 002	5	0	5
	--	--	--
	10	20	16

Third Quarter	Lec	Lab	Cr
Electronics 134	5	0	5
Electronics 184	0	15	5
Telecommunications 131	5	0	5
Telecommunications 181	0	5	1
	--	--	--
	10	20	16

Fourth Quarter	Lec	Lab	Cr
Telecommunications 122	5	0	5
Telecommunications 172	0	10	3
Communication Skills 111	5	0	5
Math 144	5	0	5
Physics 122	5	0	5
	--	--	--
	20	10	23

Sophomore Year

First Quarter	Lec	Lab	Cr
Electronics 212	5	0	5
Electronics 262	0	15	5
Telecommunications 141	5	0	5
Telecommunications 191	0	5	1
	--	--	--
	10	20	16

Second Quarter	Lec	Lab	Cr
Telecommunications 221	5	0	5
Telecommunications 271	0	15	5
Electronics 222	5	0	5
Electronics 272	0	5	1
	--	--	--
	10	20	16

Third Quarter	Lec	Lab	Cr
Electronics 235	5	0	5
Electronics 285	0	15	5
Economics 111	5	0	5
Telecommunications 123	5	0	5
	--	--	--
	15	15	20

Fourth Quarter	Lec	Lab	Cr
Telecommunications 244	5	0	5
Telecommunications 294	0	15	5
Psychology 111	5	0	5
Telecommunications 121	5	0	5
	--	--	--
	15	15	20

Diploma

First Quarter	Lec	Lab
Telecommunications 111	5	0
Telecommunications 161	0	10
Math 001	5	0
Science 141	5	0
Physics 111	5	0
	--	--
	20	10

Second Quarter	Lec	Lab
Telecommunications 244	5	0
Telecommunications 294	0	10
Math 001	5	0
Science 142	5	0
Physics 122	5	0
	--	--
	20	10

Third Quarter	Lec	Lab
Telecommunications 131	5	0
Telecommunications 181	0	5
Telecommunications 122	5	0
Telecommunications 172	0	15
	--	--
	10	20

Fourth Quarter	Lec	Lab
Telecommunications 141	5	0
Telecommunications 191	0	5
Psychology 111	5	0
Psychology 111	5	0
Communication Skills 111	5	0
Telecommunications 121	0	10
	--	--
	15	15

Course Descriptions for
Telephone Communication Technology
Alabama Technical College
Gadsden, Alabama

Business Education 101 - Basic Typewriting

This course stresses keyboard mastery, control of machine operations and basic skills development.

Communication Skills 111 - Communication Skills

This course is designed to help the student in the fundamental skill of communications. This course includes a review and study of basic grammar, punctuation, spelling and defining trade terms, sentence structure, filling out forms, technical reading, and oral communication. This course is individualized so that the student may progress at his own speed.

Economics 111 - Economics

Economics teaches you that "economics" is everywhere, and is at work all the time, in everything. This course focuses the student's attention on his/her personal economics as well as national and international economics.

The student learns to relate himself/herself with the world as a whole.

Electronics 111 - D.C. Fundamentals

Beginning with the basic theory of electricity, the course introduces the student to the fundamental laws and theorems of direct current as applied to series, parallel, and series-parallel circuits. Kirchhoff's laws, network theorems, D-C meters, conductors and insulators, Ohm's law, batteries, magnetism, and electromagnetic induction are broad areas covered.

Electronics 122 - A.C. Fundamentals

In this course the student will learn the fundamentals of alternating current as applied to circuits containing components such as resistors, capacitors, inductors, and transformers. The student will analyze and solve A-C circuit problems involving resistance, capacitance, inductance, and impedance. In conclusion, the student will learn the fundamental construction and operating characteristics of vacuum tubes.

Electronics 134 - Basic Electronic Circuits

This course covers the more basic of the commonly utilized circuits found in all areas of electronics. These include the various rectifier, filter, and voltage regulating circuits; linear solid-state and vacuum-tube amplifiers for audio, r-f, video, and d-c; typical audio systems including loudspeakers, microphones, record playing and tape recording equipment and circuits; sinusoidal oscillator circuits; AM and FM modulation, transmitters, and receivers; electromagnetic waves; antennas, and radiation. The entire course emphasizes learning the typical circuits, their principles of operation, and troubleshooting defective circuits.

Electronics 161 - D.C. Fundamentals Laboratory

This laboratory course provides the hands-on experiences that are needed to supplement the D.C. Fundamentals course.

Electronics 172 - A.C. Fundamentals Laboratory

This laboratory course provides the hands-on experiences that are needed to supplement the A.C. Fundamentals course.

Electronics 184 - Basic Electronic Circuits Laboratory

This laboratory course and the Basic Electronic Systems Laboratory course, EL 195, are to be taken sequentially and they provide the hands-on experiences that are needed to supplement the Basic Electronic Circuits and Basic Electronics Systems courses.

Electronics 212 - Digital Fundamentals

This is a beginning course in digital technology. The coverage of programmable logic and bus-system organizing concepts contributes to the primary goal which is to give the student both a solid grounding in modern digital integrated circuits and a foundation for future study of microprocessors.

It introduces logic fundamentals and examines the internal circuitry and characteristics of integrated circuit logic gates (TTL, MOS, C-MOS, ECL and I^2L).

Truth tables and Boolean algebra are used to analyze and design logic circuits. Flip-flops are discussed with emphasis on type D and J-K flip-flops. The generation, shaping and delaying of logic pulses is presented.

Electronics 212 - Digital Fundamentals (continued)

A comprehensive study of counter circuits occurs as well as the examination of the theory and practice of using flip-flops connected as shift registers. RAM's and ROM's are covered along with a discussion of special data communications codes such as ASCII and EBCDIC are discussed.

Electronics 222 - Microwave Fundamentals

Microwave Technology is a course covering elementary field theory, transmission line fundamentals, transmission of power at lines. In addition, the course includes graphical representation of transmission line characteristics, the Smith chart and its uses at microwave frequencies, and transmission line measurements. Waveguide elements, microwave antennas, cavities, wavemeters, and filters are also included. The student gains a working knowledge of microwave ferrite devices, microwave amplifying devices, and oscillators for microwave frequencies, including an introduction to masers and lasers. Basic radar system fundamentals are also included.

Electronics 235 - Computer Fundamentals/Microprossor

This course has been planned as an introduction in the use of micro-computers. It shows how the computer operates at the machine language level and how to program a microcomputer using assembly language.

The details of the Motorola MC6800 microprocessor are covered and how it interfaces with the outside world through the bus system and peripheral controller. Although the course deals with the 6800 processor, the concepts learned will apply to other microprocessors.

Electronics 262 - Digital Fundamentals Laboratory

This course provides the hands-on experiences that are needed to supplement the Digital Fundamentals course.

Electronics 272 - Microwave Laboratory

The microwave laboratory course is designed to give the student experiences in the operation of microwave equipment and the use of microwave test equipment. The course reinforces the materials taught in the companion course Microwave Fundamentals, EL 222. The equipment setups in the laboratory emphasize measurements, troubleshooting, and the use of techniques peculiar to frequencies above 1-GHz.

Electronics 285 - Computer/Microprocessor Laboratory

This course provides the hands-on experiences that are needed to supplement the Computer Fundamentals/Microprocessor course EL 235.

Math 001 - Basic Math

A treatment of fundamental concepts and operation of basic math. Topics include: Addition, subtraction, multiplication, division of whole numbers, fractions, decimals, and reducing fractions, percent, interest, the metric system, area, perimeter, and circumference, surface area and volume.

Math 002 - Basic Algebra

A basic treatment of the fundamental concepts and manipulations, topics include laws of exponents, symbols of grouping and order of operation, polynominals, factoring, and special products, simple equations, and prime factors of expressions.

Math 144 - Boolean Algebra

This course presents a basic approach to various numbering systems and particularly those that pertain to computers. Also, a treatment of the concepts of Boolean Algebra dealing primarily with postulates, theorems, and fundamental laws, factoring and simplifying functions relating to computer circuitry.

Physics 111 - Electrical Physics

This course is designed as a beginning course since it does not require trigonometry as a prerequisite; however, a knowledge of high school algebra is required. The course begins with the electron theory and progresses through A-C circuitry. Sound and light are also covered.

Physics 122 - Electronic Physics

This course is designed as a beginning course since it does not require trigonometry as a prerequisite; however, a knowlege of high school algebra is required. The course covers forces, energy, basic machines, properties of matter, and heat.

Psychology 111 - Psychology

This course deals with personal Psychology at home and at work. The student learns how to deal with himself/herself objectively. He/She also learns how to get along with others, and also the importance of getting along with relatives, friends, and co-workers. The student should have a better understanding of self and others.

Science 141 - Basic Electricity

A basic d.c. science course explaining how electricity is produced. It also introduces the student to d.c series and parallel circuits as well as Ohm's Law and Kirchhoff's Law.

Science 142 - Basic A.C.

This is a basic course explaining alternating current, inductive circuits, and capacitive circuits. Series, parallel, and resonant circuits are covered as they apply to alternating current. Transformers and elementary generators are also discussed.

Telecommunications 111 Basic Installation and Repair

This course will cover basic knowledge of a station installer who is employed by the telephone company. It includes station wiring, circuit reading, outside plant work, safety, and work habits.

Telecommunications 121 - Supply Inventory

This course will cover procedures used in inventory of a simulated Telephone Warehouse or Supply House. All types of key telephone apparatus, installation, repair parts, and associated outside plant parts, will be inventoried.

It introduces to the students, procedures needed for a good working inventory system, including a part number and name. Also, there will be a student check-in, check-out form to identify the individual parts taken of supply.

Telecommunications 122 - Key Systems

This course will cover station repair, inside and outside plant construction, key telephone installation and repair, key telephone units, key system planning, and related equipment.

Telecommunications 123 - Outside Plant Technology

This course will cover all procedures involved in the installation and maintenance of outside cable and associated equipment. Emphasis will be placed on safety and proper installation of aerial and underground cable. The student will learn to climb a telephone pole and perform all necessary tasks in a safe and professional manner while on the pole.

Telecommunications 131 - Transmission Fundamentals

The course Transmission Fundamentals is designed to give the student a working knowledge of telephone voice-frequency transmissions over wires or cable. This also includes telephone signalling and supervision equipment fundamentals, operation of the basic telephone set, telephone plant and personnel protection equipment and safety measure, and the basic techniques of telephone loop treatment.

The student is taught the uses of basic test equipment for transmission measurements and how to interpret the results in terms of acceptable performance.

Included throughout the course is emphasis on troubleshooting of transmission failures.

Telecommunications 141 - Station Carrier

This laboratory course will run along with course TC 191 and will deal primarily with station and subscriber carrier systems. It will cover the installation and maintenance of these systems.

Telecommunications 161 - Basic Installation and Repair Laboratory

To familiarize students with basic telephone installation, repair, and how the telephone operates, from central office, outside plant to station. How to prevent accidents and work safely inside and outside plant.

Telecommunications 172 - Key Systems Laboratory

This laboratory course will cover single and multi-line telephone installation and repair. Key telephone units and systems. Key system planning, installation and repair, and related key features. This course will also cover theory of commercial sound systems installation and maintenance.

Telecommunications 181 - Transmission Fundamentals Laboratory

Introduction to station carrier system, telephone loops. How to measure telephone line voltage, ringing and different tones. The use of wire to transmit and receive at short and long distance.

Telecommunications 191 - Station Carrier Laboratory

This laboratory course is the lab course for TC 141 Station Carrier. The course consists of laboratory experiments designed to give the student practice in measurements using test equipment, basic troubleshooting and maintenance procedures, and practice in system layout and installation. Equipment used in the laboratory consists of actual multichannel and single-channel subscriber systems and typical industry test and measurement equipment.

Telecommunications 221 - Digital Electronic Private Automatic Branch Exchange

This course covers Electronic Private Automatic Branch Exchange. Features (stations, systems, and trunks) wiring, cards and programming.

Telecommunications 244 - 584-C Key Systems

This course will cover station repair, inside and outside plant construction, key telephone installation and repair, key telephone units, key system planning and related equipment.

Telecommunications 271 - Digital EPABX Laboratory

This course, EPABX (Electronic Automatic Branch Exchange), will cover all station connections and special connections, all programming of stations, trunks, special features and console.

Telecommunications 294 - 584-C Key Systems Laboratory

This laboratory course will cover single and multi-line telephone installation and repair, key telephone units and systems, key systems planning, installation and repair, and related key features. This course will also cover theory of commercial sound systems installation and maintenance.

Equipment

The equipment in the program consists of laboratory trainers in the Basic Electronics courses and actual telephone equipment in the Telecommunication laboratories. To the extent possible, they only use equipment that has a proven market and commercial acceptance.

The students are taught to install and maintain the types of systems they can expect to encounter in the work environment. The labs are arranged so the student is provided with a 4' x 4' work area that is walled on three sides. Included in that space is a work bench. This work area is assigned to the student for the entire quarter. The student also performs some functions at other locations within the lab to provide dial tone cross connects to his/her station. Every effort is made to make the training as realistic as possible by providing situations where the student must work independently as well as with other students in accomplishing tasks. The telephone system on campus also provides a great deal of hands-on training for students, in addition to the equipment contributed by the independent telephone company association.

Faculty Development

The faculty uses three primary methods to keep abreast of the trends in technology.

1. New equipment and factory schools
2. Seminars and workshops
3. Self-study by the individual instructors

The instructors in the program either hold a B.S. Degree in Vocational Education or are in the process of acquiring a degree.

Placement

Placement of graduates and those that have been employed prior to graduation has been exceptional. In fact, one year a company hired not only all the graduates of the program but also their instructor.

PROGRAM: Telephone Communication Center
INSTITUTION: Seminole Community College
Sanford, Florida 32771
(305) 323-1450
CONTACT: Thomas Fetterhoff
DEGREE: Certificate of Completion
DATE BEGAN: January 1973

History

Seminole Community College opened the Telephone Technology Training Center in January 1973. The purpose of the center was to provide systematic and uniform training in all phases of telephony for industry people and those seeking employment in the industry. During the first year, 269 students were enrolled in courses covering cable splicing and repair, station installation and repair, transmission, carrier systems and NX1-D crossbar switching systems. During the second year, the center experienced a healthy increase in enrollment with a total of 465 students. The number of courses offered and types of students attending the courses has continued to increase since that time.

As the demand for training has increased, the college has provided new and larger quarters to house the center. A long term lease was negotiated with the Sanford Airport Authority. The training center was then moved to a 19,000 square foot building near the main campus. The classes have been overhauled periodically to keep pace with the expanding industry.

Advisory Committee

The program has been supported throughout its existence by companies and manufacturers who want to train their employees on specialized equipment and want to hire graduates who have completed the training program at Seminole Community College. They include Stromberg-Carlson, North Electric Co., Vicom, Wescom, Nothern Telecom and ITT Corporation.

The Program

There are two programs currently offered at the Center which will be described in this chapter. They are Basic Cable Splicer (444 hours of instruction) and Basic Installer-Repariman (also 444 hours of instruction). Each program will be described individually.

Basic Cable Splicer

Cable splicers must be knowledgeable in outside plant construction and equipment. They should be able to climb poles with hooks and have no fear of heights. Duties consist of reading and interpreting construction prints, cable records and wiring diagrams, being able to identify various cables, and cable equipment, and being able to install the same. The cable splicer must be willing to work outdoors. In most situations she/he will not be working under direct supervision. Cable splicers generally complete line connections in a telephone system. They work on aerial platforms, in manholes, or in basements of large commercial building. They connect individual wires within the cable by matching colors of wires within a cable when lines have to be changed.

This program is in the Industrial Education Division. The objective is to prepare persons for initial employment, to upgrade or retrain persons already employed, or to provide the apprenticeship-related coursework necessary to insure successful employment in the Communications filed.

The plan of instruction includes specialized classroom and practical experiences concerned with the assembly, installation, operation, maintenance, and repair of communications equipment and systems of all types. Covered is equipment such as industrial and entertainment sound systems, data processing equipment, telephone dial systems, two-way radios, central circuits, and hearing aids.

The objectives of this course are the following:

A. Student will be able to climb poles with hooks and be able to work aloft.

B. Student will be able to identify and describe various station equipment, analyze its operation and be able to install, repair and maintain such equipment.

C. Student will be able to read and interpret basic telephone schematics and wiring diagram, and use them to wire equipment.

D. Student will apply safe and proper methods in using tools and material.

E. With proper orientation, student will acquire proper motivation and attitude towards employer and customer.

Prerequisites include being a high school graduate or equivalent, electrical and mechanical aptitude, normal color perception, eighth grade reading and math levels, and must be in good physical condition with no recurring back or spine injuries.

The course outline follows.

COURSE OUTLINE

I. ORIENTATION 6 Hours

Objective: all students will know and understand the requirements of the cable splicing course. They will know and follow the prescribed policy and safety rules of the Telephone Training Center.

A. Explanation of course and school policy

1. "Cable Splicing" meaning and introduction
2. class hours
3. facilities
4. use of spec books
5. secrecy of communication

B. Evaluation and motivation

1. pre-test
2. unit testing
3. performance tests
4. ethics
5. employer - employee relations
6. employee - customer relations
7. attitude

C. Safety

1. on the job
2. in class

    a. reporting accidents
    b. accident insurance
    c. accidents at home

D. Safety equipment

1. eye protection, hard hats, shoes, clothing
2. fire extinguisher, first-aid kit, etc....

II. BASIC MATHEMATICS 30 Hours

Objective: the basic mathematics section of the course is designed to teach the student the necessary mathematic skills that are required in the basic electricity section of this course.

The basic mathematics section is designed as a self paced course of instruction and is prepared in a module design.

A. Introduction to arithmetic

1. select the correct place or position of digits in given whole numbers
2. round off whole numbers
3. solve problems in addition of whole numbers
4. solve problems in subtraction of whole numbers
5. solve problems in multiplication of whole numbers
6. solve problems in division of whole numbers

B. Decimals

1. express given fractions as decimals
2. express given decimals as fractions
3. solve problems in the addition of decimals
4. solve problems in the subtraction of decimals
5. solve problems in the multiplication of decimals
6. solve problems in the division of decimals

C. Signed numbers

1. select the definition of a signed number
2. select the definition of an absolute value
3. select the rule for addition of signed numbers
4 with like signs
5. solve problems in addition of signed numbers
6 with like signs
7. select the rule for addition of signed numbers with unlike signs
8. solve problems in addition of signed numbers with unlike signs
9. select the rule for subtraction of signed numbers
10. solve problems in subtraction of signed numbers
11. select the rule for multiplication of signed numbers
12. solve problems in multiplication of signed numbers
13. select the rule for division of signed numbers with like signs
14. solve problems in division of signed numbers with like signs
15. select the rule for division of signed numbers with unlike signs
16. solve problems in division of signed numbers with unlike signs

D. Powers of ten

1. select the definition of a base
2. select the definition of an exponent
3. select the definition of scientific notation
4. convert given numbers into scientific notation
5. convert numbers given in powers of ten into scientific notation
6. round off numbers expressed in scientific notation
7. solve problems in addition and subtraction of powers of ten
8. solve problems in multiplication of powers of ten
9. solve problems in division of powers of ten
10. square quantities utilizing powers of ten
11. extract square roots of powers of ten
12. solve problems involving multiple operations using the powers of ten

E. Conversion of electrical units

1. identify the metric prefixes, their abbreviations and the powers of ten of the seven metric prefixes commonly used in electronics
2. solve problems involving the use of the metric prefixes

F. Solving formulas

1. match statements defining certain terminology to the terms they described
2. select, from a list of statements, the statements that correctly describe a solved formula
3. solve problems for an unknown value containing addition and subtraction only
4. solve problems for an unknown value containing multiplication and division only
5. solve problems for an unknown value containing addition, subtraction, multiplication, and division
6. select from a list of statements, the statement that describes the action taken when the unknown value is squared
7. select, from a list of statements, the statement that describes the action taken when the unknown value is indicated to be a square root
8. solve a problem containing a fraction times a whole number
9. solve reciprocal formulas by substitution
10. analyze changes made in formulas to determine the effect thechange will have on the unknown value

G. Fractions

1. identify the two parts of fractions
2. reduce fractions to their lowest terms by determining the lowest common denominator
3. solve problems in addition of fractions
4. solve problems in subtraction of fractions
5. solve problems in multiplication of fractions
6. solve problems in division of fractions

H. Percentages

1. change given decimals to percentages
2. change given percentages to decimals
3. solve problems finding percentages
4. solve problems by finding what percent one number is of another number
5. solve problems by finding a number when the percent is known

I. Ratio and proportion

1. select, from a list of statements, the statement that defines a ratio
2. select, from a list of statements, the statement that defines a proportion
3. select, from a list of statements, the statement that defines direct proportion
4. select, from a list of statements, the statement that defines inversse proportion
5. solve problems using inverse proportion

J. Mathematics of angles

1. right angles
2. sides and angles
3. functions
4. table of natural functions
5. solving problems
6. vector analysis

K. Square and square roots

1. select, from a list of statements, the statement that defines the square of a number
2. select, from a list of statements, the statement that defines the square root of a number
3. solve problems by finding the square root of whole numbers and decimals

III. BASIC ELECTRICITY 60 HOURS

Objective: student will be able to identify and explain functions of basic components, and be able to apply basic formulas in series, parallel and combination AC and DC circuits.

This section of the course is designed as a self paced program allowing each student to proceed at his/her own learning level.

A. Electricity and the electron

   1. what electricity does
   2. what electricity is
   3. movement inside a solid wire
   4. a word on theory
   5. the electron and two other particles
   6. the atom
   7. wire and other materials
   8. composition of matter
   9. space between atomic particles

B. Voltage

   1. EMF from chemical action
   2. magnetism
   3. electromagnetic induction
   4. AC voltage
   5. the uses of AC and DC
   6. measuring voltage

C. Resistance

   1. characteristics of resistance
   2. resistors
   3. resistor values
   4. ohmmeters

D. Measuring current and voltage in series circuits

   1. measuring current in a series circuit
   2. voltage in a series circuit
   3. using the multimeter as a voltmeter

E. Relationships of current, voltage, and resistance

   1. voltage, resistance, and current
   2. the Ohm's Law formula
   3. power
   4. internal resistance
   5. troubleshooting series circuits

F. Parallel circuits

1. rules for voltage and current
2. rules for resistance and power
3. variational analysis
4. troubleshooting parallel circuits

G. Combination circuits and voltage dividers

1. solving complex circuits
2. voltage reference
3. voltage dividers

H. Induction

1. electromagnetism
2. inductors and flux density
3. inducing voltage
4. inductance and induction

I. Relationships of current, counter EMF, and voltage in LR circuits

1. rise and decay of current and voltage
2. LR time constant
3. using universal TC chart
4. inductive reactance
5. relationships in inductive circuits
6. phase relationships

J. Transformers

1. transformer construction
2. transformer theory and operation
3. turns and voltage ratios
4. power and current
5. transformer efficiency
6. semiconductor rectifiers

K. Capacitance

1. the capacitor
2. theory of capacitance
3. total capacitance
4. RC time constant
5. capacitive reactance
6. phase and power relationships
7. capacity design consideration

L. Series AC resistive-reactive circuits

1. voltage and impedance in AC series circuits
2. vector computations
3. rectangular and polar notation
4. variational analysis of series RL circuits
5. frequency discrimination in RL circuits
6. series RC circuits

M. Series AC RLC circuits and resonance

1. solving RLC circuits
2. resonant frequency in series circuits
3. conditions of series resonance
4. experiments with series resonance

N. Parallel AC resistive-reactive circuits

1. solving for quantities in RL parallel circuits
2. variational analysis of RL parallel circuits
3. parallel RC and RCL AC circuits
4. parallel resonance
5. effective resistance in parallel RL circuits
6. parallel resonance experiment

IV. BASIC COMPETENCY, AND EMPLOYABILITY 60 Hours

Skills: basic competency skills are used everyday by people everywhere. Students entering this everyday world of work must be prepared to apply their school-based skills to this new environment. These skills are an integral part of the daily interaction and communications with others necessary for independent living.

Employability skills are the non-technical, cross-vocational skills related to getting and keeping a job. These skills include such abilities as choosing an occupation, filling out an application form, managing personal finances, getting along with people on the job, practicing good work habits, and resigning properly from a job.

A. Basic competency

1. take home pay
2. a personal budget
3. state sales tax
4. banking - checks and check stubs
5. saving for a purchase
6. repaying a loan
7. charge accounts
8. discounts
9. unit pricing
10. help wanted
11. locating information in a newspaper
12. the yellow pages
13. sports averages
14. postal rates
15. how cold is it?
16. graphs give information
17. a big budget
18. time, rate, and distance
19. words of warning
20. local bus route

B. Personal finances

1. Paychecks and taxes

    a. collecting your pay
    b. learning about fringe benefits
    c. paying taxes
    d. filing Federal Income Tax

2. Spending your money
    a. learning smart shopping rules
    b. buying on credit
    c. paying your bills on time
    d. keeping a budget
    e. developing a budget
    f. finding out about insurance
    g. borrowing money

3. Banking
    a. opening a savings account
    b. filling out a deposit slip
    c. opening a checking account
    d. balancing your checkbook

C. Basic banking operations

1. banking procedures for savings and checking accounts
2. opening accounts
3. writing checks
4. making deposits
5. maintaining checking account balances
6. writing dates and amounts
7. figuring income and expenses

D. Your job search

1. getting ready
    a. setting aside time for your job search
    b. getting a social security number
    c. preparing your personal fact sheet

2. getting leads
    a. finding job openings
    b. finding part-time jobs
    c. using employment agencies
    d. looking for government jobs
    e. reading the want ads
    f. keeping records on your action plan
    g. starting your job card file

3. making contact
    a. visiting employers
    b. writing a letter of application
    c. phoning about a job lead

E. Applying for a job

  1. before you apply

    a. how employers get information about applicants
    b. official papers needed for employment
    c. your resume

  2. filling out an application form

    a. neatness
    b. completeness and correctness
    c. words on the application form
    d. open-ended questions

  3. interviewing for a job

    a. tips for a successful interview
    b. your interview
    c. the interviewer's questions
    d. your appearance at the interview

  4. after you apply

    a. your follow-up letter
    b. pre-employment tests
    c. before you say "yes"
    d. failing to get a job

F. Good work!

  1. making your time count

    a. absent or late - what can happen
    b. if you can't come to work, call!
    c. when you get there, work!

  2. getting to know the job

    a. your first day at work
    b. help - when you need it
    c. nobody's perfect

  3. practicing good habits at work

    a. honesty on the job
    b. phone messages and manners
    c. safety first

4. doing the job right
    a. a better way to do the job
    b. waste not, want not
    c. neatness counts
    d. instructions worth following

5. looking good
    a. good grooming
    b. food for thought

V. POLE CLIMBING 60 Hours

Objective: student will develop the basic skills of pole climbing, to enable him to work aloft in a safe manner at the 25' level. To properly maintain various support devices, and to make him aware of potential hazards resulting from damage and deteriorated poles and high voltage electrical contacts.

A. Apparel

1. wearing
2. protective

B. Safety and equipment

1. checking poles and strands
2. climber care and maintenance
3. conditioning
4. safety straps and body belts

C. Pole climbing procedures

1. practice ascending-descending
2. safety
3. power clearance

D. Ladders and ropes

1. transportation
2. securing ladders aloft

E. Evaluation

1. performance test
2. written tests

VI. CABLE SPLICING 228 Hours

Objective: student will be able to differentiate between outlined cables and cable splicing operations, and be able to explain those operations. Student will be able to correctly splice paper and plastic cables according to industry standards, in the most efficient and safe manner.

A. Ethics

1. honesty
2. self confidence
3. self control
4. team work
5. dependability

    a. promptness
    b. accuracy

B. Tools and material

1. tools

    a. hand tools
    b. power tools
    c. test equipment

2. material

C. Underground safety procedures

1. testing for gas
2. plugging ducts
3. barricading manholes

D. Cable identification

1. size
2. gauge
3. type
4. use

E. Construction prints

1. symbols
2. codes
3. notes

F. Color code

1. pair
2. group
3. super group

G. Splicing techniques

    1. aerial
    2. buried
    3. underground

        a. twist and solder
        b. AMP machines
        c. 3M module
        d. scotch lock
        e. "B" connector

            1) straight splice
            2) butt splice
            3) fold back
            4) clear capping
            5) bunching and grounding

H. Terminals and cross connect boxes

    1. affect of placement

        a. top fed
        b. bottom fed
        c. fixed count
        d. ready access

    2. proper placement
    3. dedicated plant

I. Pedestals

    1. location

        a. pole mounted
        b. stake mounted

    2. grounding

        a. hardware
        b. cable bullet bonds

    3. splicing method
    4. numbering

        a. plastic numbers
        b. aluminum numbers

J. Bonding and grounding

    1. temporary bonding
    2. permanent bonding
    3. grounding hardware

K. Forming and racking cable

  1. aerial cable
  2. manholes
  3. vaults

L. Tagging cable pairs

  1. 76C tone set
  2. HE7 tone set
  3. head set
  4. amplifier
  5. probe

M. Auxiliary sleeve

  1. sleeve preparation
  2. sequence and type of tape layers
  3. bonding
  4. inner wrap

N. Main sleeve

  1. torch wiping
  2. pot wiping
  3. safety rules

O. Cable acceptance test

  1. megger
  2. head set and battery

P. Load coils

  1. aerial
  2. buried
  3. underground

Q. Cable throw

  1. working cable
  2. nonworking cable

R. Evaluation

  1. written test
  2. performance test

The plan of instruction includes specialized classroom and practical experiences consisting of lectures, supplemented with demonstration and laboratory experiments. The following resources are used.

Basic Radio Vol. I, by Marvin Tepper, Hayden Book Co., New Jersey

Basic Radio Vol II, by Marvin Tepper, Hayden Book Co., New Jersey

Foundations of Electronics, by William A. Brigerman, Jr., Electronic Aids Inc., Maryland

Experiments in Basic Electricity Electronics, by Morris Tischler, Electronic Aids Inc., Maryland

Cable Splicing Manual, Winter Park Telephone Co.

Cable Practices, United Telephone Co. of Florida

Cable Practices, Bell Systems

Cable Practices, General Telephone Equipment

Cable Practices, Rural Electrification Administration.

Puregas Pressurization Practices, General Cable Corp.

Equipment Manuals, D. O. Creasman Electronics Inc., Dynatel Corp., Hewlett Packard, Delcon

Faculty

There are six members of the faculty which teach in this program. Their backgrounds are in electronics.

Basic Installer-Repairman

The largest group of employees in the telephone industry is the telephone serviceperson. Because of the variety of work that is performed by this group, they can be broken down by job functions: Station Installer, Station Repairperson, Key Installer, etc. Telephone Installers install and service single, two and three line telephones in homes and businesses. They connect telephones to outside service wires and sometimes must climb poles to make these connections.

Repairpersons locate trouble on customer equipment and make repairs to restore service. They also are required to service customers when new lines or different services are requested.

The course is included in the Industrial Education Division. The objective of the course is to prepare persons for initial employment, to upgrade or retrain persons already employed, or to provide the apprenticeship-related coursework necessary to insure successful employment in the Communications field.

The plan of instruction includes specialized classroom and practical experiences concerned with the assembly, installation, operation, maintenance and repair of communication equipment and systems of all types. Covered is equipment such as industrial and entertainment sound systems, data processing equipment, telephone dial systems, two-way radios, central cirucits and hearing aids.

The general objectives are:

A. Student will be able to climb poles with hooks and be able to work aloft.

B. Student will be able to identify and have a workable knowledge of cable and cable equipment, analyze its operation and be able to install, repair and maintain such equipment.

C. Student will be able to read and interpret basic telephone schematics and wiring diagram, and use them to wire equipment.

D. Student will apply safe and proper methods in using tools and material, in the most efficient and workable manner.

E. With proper orientation, student will acquire proper motivation and attitude towards employer and customer.

Prerequisites include being a high school graduate or the equivalent, electrical and mechanical aptitude, normal color perception, eighth grade reading and math levels and must be in good physical condition with no recurring back or spin injuries.

The course is designed to develop thorough technical instruction and hands-on experiences, the necessary procedures, skills and knowledge for successful entry into the telephone installation field. This course also provides the necessary foundation for further training in related subjects or career fields. The emphasis on the manipulative skills, is to have the student master the proper use of tools and equipment. The technical instruction covers circuit reading, wiring diagrams, AC-DC theory relating to the telephone industry, and administrative aspects of installation work.

The course outline follows.

COURSE OUTLINE

I. ORIENTATION 6 Hours

Objective: all students will know and understand the requirements of the installation repair course. They will know, and follow the prescribed policy and safety rules of the Telephone Training Center.

A. Explanation of course and school policy

1. "Station Installer" meaning and introduction
2. Class hours
3. facilities
4. use of spec books
5. secrecy of communication

B. Evaluation and motivation

1. pre-test
2. unit testing
3. performance tests
4. ethics
5. employer - employee relations
6. employee - customer relations
7. attitude

C. Safety

1. on the job
2. in class

    a. reporting accidents
    b. accident insurance
    c. accidents at home

D. Safety equipment

1. eye protection, hard hats, shoes, clothing
2. fire extinguisher, first-aid kit, etc....

II. BASIC MATHEMATICS 30 Hours

Objective: the basic mathematics section of the course is designed to teach the student the necessary mathematic skills that are required in the basic electricity section of this course.

The basic mathematics section is designed as a self paced course of instruction and is prepared in a module design.

A. Introduction to arithmetic

1. select the correct place or position of digits in given whole numbers
2. round off whole numbers
3. solve problems in addition of whole numbers
4. solve problems in subtraction of whole numbers
5. solve problems in multiplication of whole numbers
6. solve problems in division of whole numbers

B. Decimals

1. express given fractions as decimals
2. express given decimals as fractions
3. solve problems in the addition of decimals
4. solve problems in the subtraction of decimals
5. solve problems in the multiplication of decimals
6. solve problems in the division of decimals

C. Signed numbers

1. select the definition of a signed number
2. select the definition of an absolute value
3. select the rule for addition of signed numbers
4 with like signs
5. solve problems in addition of signed numbers
6 with like signs
7. select the rule for addition of signed numbers with unlike signs
8. solve problems in addition of signed numbers with unlike signs
9. select the rule for subtraction of signed numbers
10. solve problems in subtraction of signed numbers
11. select the rule for multiplication of signed numbers
12. solve problems in multiplication of signed numbers
13. select the rule for division of signed numbers with like signs
14. solve problems in division of signed numbers with like signs
15. select the rule for division of signed numbers with unlike signs
16. solve problems in division of signed numbers with unlike signs

D. Powers of ten

1. select the definition of a base
2. select the definition of an exponent
3. select the definition of scientific notation
4. convert given numbers into scientific notation
5. convert numbers given in powers of ten into scientific notation
6. round off numbers expressed in scientific notation
7. solve problems in addition and subtraction of powers of ten
8. solve problems in multiplication of powers of ten
9. solve problems in division of powers of ten
10. square quantities utilizing powers of ten
11. extract square roots of powers of ten
12. solve problems involving multiple operations using the powers of ten

E. Conversion of electrical units

1. identify the metric prefixes, their abbreviations and the powers of ten of the seven metric prefixes commonly used in electronics
2. solve problems involving the use of the metric prefixes

F. Solving formulas

1. match statements defining certain terminology to the terms they described
2. select, from a list of statements, the statements that correctly describe a solved formula
3. solve problems for an unknown value containing addition and subtraction only
4. solve problems for an unknown value containing multiplication and division only
5. solve problems for an unknown value containing addition, subtraction, multiplication, and division
6. select from a list of statements, the statement that describes the action taken when the unknown value is squared
7. select, from a list of statements, the statement that describes the action taken when the unknown value is indicated to be a square root
8. solve a problem containing a fraction times a whole number
9. solve reciprocal formulas by substitution
10. analyze changes made in formulas to determine the effect thechange will have on the unknown value

G. Fractions

1. identify the two parts of fractions
2. reduce fractions to their lowest terms by determining the lowest common denominator
3. solve problems in addition of fractions
4. solve problems in subtraction of fractions
5. solve problems in multiplication of fractions
6. solve problems in division of fractions

H. Percentages

1. change given decimals to percentages
2. change given percentages to decimals
3. solve problems finding percentages
4. solve problems by finding what percent one number is of another number
5. solve problems by finding a number when the percent is known

I. Ratio and proportion

1. select, from a list of statements, the statement that defines a ratio
2. select, from a list of statements, the statement that defines a proportion
3. select, from a list of statements, the statement that defines direct proportion
4. select, from a list of statements, the statement that defines inversse proportion
5. solve problems using inverse proportion

J. Mathematics of angles

1. right angles
2. sides and angles
3. functions
4. table of natural functions
5. solving problems
6. vector analysis

K. Square and square roots

1. select, from a list of statements, the statement that defines the square of a number
2. select, from a list of statements, the statement that defines the square root of a number
3. solve problems by finding the square root of whole numbers and decimals

III. BASIC ELECTRICITY 60 HOURS

Objective: student will be able to identify and explain functions of basic components, and be able to apply basic formulas in series, parallel and combination AC and DC circuits.

This section of the course is designed as a self paced program allowing each student to proceed at his/her own learning level.

A. Electricity and the electron

1. what electricity does
2. what electricity is
3. movement inside a solid wire
4. a word on theory
5. the electron and two other particles
6. the atom
7. wire and other materials
8. composition of matter
9. space between atomic particles

B. Voltage

1. EMF from chemical action
2. magnetism
3. electromagnetic induction
4. AC voltage
5. the uses of AC and DC
6. measuring voltage

C. Resistance

1. characteristics of resistance
2. resistors
3. resistor values
4. ohmmeters

D. Measuring current and voltage in series circuits

1. measuring current in a series circuit
2. voltage in a series circuit
3. using the multimeter as a voltmeter

E. Relationships of current, voltage, and resistance

1. voltage, resistance, and current
2. the Ohm's Law formula
3. power
4. internal resistance
5. troubleshooting series circuits

F. Parallel circuits

1. rules for voltage and current
2. rules for resistance and power
3. variational analysis
4. troubleshooting parallel circuits

G. Combination circuits and voltage dividers

1. solving complex circuits
2. voltage reference
3. voltage dividers

H. Induction

1. electromagnetism
2. inductors and flux density
3. inducing voltage
4. inductance and induction

I. Relationships of current, counter EMF, and voltage in LR circuits

1. rise and decay of current and voltage
2. LR time constant
3. using universal TC chart
4. inductive reactance
5. relationships in inductive circuits
6. phase relationships

J. Transformers

1. transformer construction
2. transformer theory and operation
3. turns and voltage ratios
4. power and current
5. transformer efficiency
6. semiconductor rectifiers

K. Capacitance

1. the capacitor
2. theory of capacitance
3. total capacitance
4. RC time constant
5. capacitive reactance
6. phase and power relationships
7. capacity design consideration

L. Series AC resistive-reactive circuits

1. voltage and impedance in AC series circuits
2. vector computations
3. rectangular and polar notation
4. variational analysis of series RL circuits
5. frequency discrimination in RL circuits
6. series RC circuits

M. Series AC RLC circuits and resonance

1. solving RLC circuits
2. resonant frequency in series circuits
3. conditions of series resonance
4. experiments with series resonance

N. Parallel AC resistive-reactive circuits

1. solving for quantities in RL parallel circuits
2. variational analysis of RL parallel circuits
3. parallel RC and RCL AC circuits
4. parallel resonance
5. effective resistance in parallel RL circuits
6. parallel resonance experiment

IV. BASIC COMPETENCY, AND EMPLOYABILITY 60 Hours

Skills: basic competency skills are used everyday by people everywhere. Students entering this everyday world of work must be prepared to apply their school-based skills to this new environment. These skills are an integral part of the daily interaction and communications with others necessary for independent living.

Employability skills are the non-technical, cross-vocational skills related to getting and keeping a job. These skills include such abilities as choosing an occupation, filling out an application form, managing personal finances, getting along with people on the job, practicing good work habits, and resigning properly from a job.

A. Basic competency

1. take home pay
2. a personal budget
3. state sales tax
4. banking - checks and check stubs
5. saving for a purchase
6. repaying a loan
7. charge accounts
8. discounts
9. unit pricing
10. help wanted
11. locating information in a newspaper
12. the yellow pages
13. sports averages
14. postal rates
15. how cold is it?
16. graphs give information
17. a big budget
18. time, rate, and distance
19. words of warning
20. local bus route

B. Personal finances

1. Paychecks and taxes

    a. collecting your pay
    b. learning about fringe benefits
    c. paying taxes
    d. filing Federal Income Tax

2. Spending your money
    - a. learning smart shopping rules
    - b. buying on credit
    - c. paying your bills on time
    - d. keeping a budget
    - e. developing a budget
    - f. finding out about insurance
    - g. borrowing money

3. Banking
    - a. opening a savings account
    - b. filling out a deposit slip
    - c. opening a checking account
    - d. balancing your checkbook

C. Basic banking operations

1. banking procedures for savings and checking accounts
2. opening accounts
3. writing checks
4. making deposits
5. maintaining checking account balances
6. writing dates and amounts
7. figuring income and expenses

D. Your job search

1. getting ready
    - a. setting aside time for your job search
    - b. getting a social security number
    - c. preparing your personal fact sheet

2. getting leads
    - a. finding job openings
    - b. finding part-time jobs
    - c. using employment agencies
    - d. looking for government jobs
    - e. reading the want ads
    - f. keeping records on your action plan
    - g. starting your job card file

3. making contact
    - a. visiting employers
    - b. writing a letter of application
    - c. phoning about a job lead

E. Applying for a job

1. before you apply
    - a. how employers get information about applicants
    - b. official papers needed for employment
    - c. your resume

2. filling out an application form
    - a. neatness
    - b. completeness and correctness
    - c. words on the application form
    - d. open-ended questions

3. interviewing for a job
    - a. tips for a successful interview
    - b. your interview
    - c. the interviewer's questions
    - d. your appearance at the interview

4. after you apply
    - a. your follow-up letter
    - b. pre-employment tests
    - c. before you say "yes"
    - d. failing to get a job

F. Good work!

1. making your time count
    - a. absent or late - what can happen
    - b. if you can't come to work, call!
    - c. when you get there, work!

2. getting to know the job
    - a. your first day at work
    - b. help - when you need it
    - c. nobody's perfect

3. practicing good habits at work
    - a. honesty on the job
    - b. phone messages and manners
    - c. safety first

4. doing the job right

    a. a better way to do the job
    b. waste not, want not
    c. neatness counts
    d. instructions worth following

5. looking good

    a. good grooming
    b. food for thought

V. POLE CLIMBING 75 hours

Objective: student will develop the basic skills of pole climbing, to enable him to work aloft in a safe manner at the 25' level. To properly maintain various support devices, and to make him aware of potential hazards resulting from damage and deteriorated poles and high voltage electrical contact.

A. apparel

    1. wearing
    2. protective

B. safety and equipment

    1. checking poles and strands
    2. climber care and maintenance
    3. conditioning
    4. safety straps and body belts

C. pole climbing procedures

    1. practice ascending-descending
    2. safety
    3. power clearance

D. ladders and ropes

    1. transportation
    2. securing ladders aloft

E. Evaluation

    1. performance test
    2. written tests

VI. TELEPHONE INSTALLATION 230 Hours

Objective: Student will be able to differentiate between outlined telephone equipment and be able to explain its operation. Student will be able to install this equipment according to industry standards, in the most efficient and safe manner.

A. Tools - use and care

1. safety
2. hand tools
3. power tools

B. Outside plant

1. telephone cable
2. terminals
3. service transfers
4. dedicated plant

C. Attachments and surfaces

1. wood construction
2. masonry and block construction
3. plaster, stucco, sheet-rock

D. Drop and block wiring

1. pole attachments
2. building attachments
3. wiring at cable terminals
4. wiring at trailer parks

E. Underground service

1. buried service drop
2. terminating at protector
3. terminating at terminal

F. Station protection

1. protector
2. grounding methods
3. precautions

G. Station wire

1. selection of wire
2. placing of wire in building
3. fishing and concealing wire
4. spacing of various attachments
5. terminating

H. Basic principles of telephony

1. central office
2. the telephone (500 set)

I. Telephone circuit analysis

1. 500 set
2. 554 wall set
3. 502 set
4. 510 set
5. 1654 set
6. 2500 set
7. 2554 set
8. 200 set
9. 254 set

J. Auxiliary signals

1. type 136 ringer (ITT)
2. type 139 extension ringer (ITT)
3. type 75 extension ringer (ITT)
4. type 144 common audible signal (ITT)
5. F1A ringer (WE)
6. Howler and signal relay

K. Optional services

1. portable service
2. amplifying receiver hand set
3. press to talk hand set
4. amplifying transmission hand set
5. S.S.M. and S.S.P. protection
6. subscriber line carrier (A.M.L.)
7. K107A telephone loudspeaker (ITT)
8. GB416/GB416A applique unit

L. Signalling

1. terminology
2. one way buzz - two wire
3. two way buzz - three wire
4. four way buzz - six wire

M. Service orders

1. service order flow
2. service order class
3. service order codes

N. Evaluation

1. performance test
2. written test

VII. TELEPHONE REPAIR 94 Hours

Objective: student will be able to identify, isolate and repair various troubles in telephone equipment. Also be able to use basic test equipment with maximum proficiency.

A. Review

1. print reading
2. safety practices

B. Common electrical faults

1. electrical
2. mechanical
3. human

C. Identification and symptoms

1. short
2. open
3. crosses
4. ground

D. Test equipment

1. hand test set
2. 81A test set
3. C16990 test set
4. volt-ohm-meter

E. Test procedure

1. open
2. short
3. cross
4. ground

F. Drop and block wiring

G. Equipment

1. telephone sets
2. customer provided equipment
3. specialty equipment
4. A.M.L. carrier

H. Evaluation

1. written test
2. performance test

VIII. PREPAY PAYSTATIONS 30 Hours

Objective: student will be able to install and repair outlined paystation equipment.

A. Terminology

1. types of paystations
2. definitions

B. Single slot paystation - Centurion NE QSE-400

1. features
2. description
3. installation
4. installation testing
5. operation
6. maintenance

C. Single slot paystation - Automatic Electric AE-120-A,B

1. features
2. description
3. installation
4. installation testing
5. operation
6. maintenance

D. Three slot paystation NE233QA

1. features
2. description
3. installation
4. installation testing
5. operation
6. maintenance

E. Three slot paystation AE LPB-82-55

1. features
2. description
3. installation
4. installation testing
5. operation
6. maintenance

F. Evaluation

1. written test
2. performance test

Textbooks used in the course include the following:

Basic Radio Vol. I, by Marvin Tepper, Hayden Book Co., New Jersey

Basic Radio Vol. II, by Marvin Tepper, Hayden Book Co., New Jersey

Foundations of Electronics, by William A. Brigerman, Jr. Electronic Aids, Inc., Maryland

Experiments in Basic Electricity Electronics, by Morris Tischler, Electronics Aids, Inc., Maryland

Station Service Manual, Vol. I, Southern Bell System

Station Service Manual, Vol. II, Southern Bell System

Station Installation Manual, United Telephone System

Installation Specifications, Winter Park Telephone Company

G.T.E. System Practices, Automatic Electric Inc.

Telephone Instrument Maintenance Manual, ITT Telecommunications

Telephone Operations Manual, Rural Electrification Administration

Stromberg-Carlson Practices, General Dynamics

Northern Belctric Practices, North Telcom Compnay Limited

Faculty

There are six faculty members who teach in the program. Their backgrounds are in electronics.

Manufacturing and Servicing Technologies

These programs prepare students for technical careers in the computer field. This means that the fundamentals of electronics along with an understanding of digital circuitry, semiconductor and microprocessor circuit analysis, and circuit fabrication need to be included in these curricula.

Despite the many specializations in manufacturing and servicing technologies, most technicians need basically the same skills. The silicon chips and their installation are similar regardless of the machinery they control. Success in this field is basically dependent upon mastering electro-mechanical competencies.

Although the programs included in this section represent a variety of approaches used to train technicians, they generally teach students to:

- repair electronic equipment
- follow blueprints and manufacturers' specifications
- test electronic components and circuits
- replace defective parts, and
- calibrate equipment according to certain specifications.

As the electronics industry grows, there will be a continuing need for skilled technicians and engineers to design, develop, conceive, build, sell and service products.

Depending upon the emphasis, students who successfully complete these programs will be able to accept positions as computer service technicians, electronics technicians, mechanics and instumentation technicians. They will work in product development, quality control testing, fabrication systems, installation and/or maintenance of equipment and systems.

The programs in this section are at both secondary and post-secondary levels. Their descriptions will best define this growing occupational area.

References

Laux, Warren and Ted Watts Pinellas Vocational Technical Institute: One curriculum, many specialities. Florida Vocational Journal Vol 8 (4) February/March 1983 pp. 8-9

TRAINING THE TECHNICIAN: AN OVERVIEW

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RATIONALE

Releveant education and training to prepare engineering technicians is a critical concern for the productivity needs of this nation. As new and changing technologies and processes for manufacturing, construction, communication, energy, and research and development occur with great rapidity, the need for engineering assistants who can perform the "nuts-and-bolts" problem-solving tasks associated with current technology has increased significantly. Modern industrial and engineering devices that are multisystem in nature require the sort of developmental, maintenance, support, and operational personnel who can change, adjust, and adapt to new situations and utilize increasingly sophisticated hardware with a minimum of retraining. In all, this trend toward innovation as the status-quo has heightened the need for a trained technician who combines theoretical and conceptual knowledge with the manipulative, "hands-on" skill of an artisan or craftsman. It is toward this end that modern technical education must be focused. The remainder of this document offers a description of procedures necessary to train engineering technicians who can make a contribution in the emerging technologies.

PURPOSE AND OBJECTIVES

The purpose and objectives of this technician training are as follows.

Purpose

The purpose of the engineering technology program in Georgia is to produce specialists who possess the broad base of knowledge, skill, and attitude necessary to be productive in modern technical occupations that are characterized by rapid change and highly sophisticated content.

Objectives

1. To provide basic knowledge, skills, and attitude development grounded in a continuing analysis of the occupational domain to be served.
2. To produce a technician who is able to deal with the complex systems interactions that characterize modern technological environments.

3. To provide program options that allow in-depth study in specialized areas of the occupational domain beyond the basic skill level.

4. To provide for awarding of credit leading to an associate degree credential, as well as options toward other degree credentials.

5. To provide instruction that maximizes the application of knowledge, skills, and attitudes to real work situations.

6. To provide instruction that prepares the student for the complex problem-solving nature of highly technical occupations.

7. To fully coordinate the high-technology program with needs of business and industry through a systematic process of school-community-business inter-cooperation.

8. To provide a system of instruction that is fully responsive to and perceptive of the intrinsic nature of change and innovation in highly technical occupations and disciplines.

TECHNICIANS DEFINED

In general the work role of the engineering technician falls between that of the vocational-industrial tradesman and that of the professional engineer. This is a broad range which is ill-defined in practice, having gray areas of work requirements at either end of the continuum and at many points in between. Perhaps the best way to define a technician is by a summary of tasks performed and the accompanying skills required. This must of necessity be done in a broad and generalized fashion with provisions for more specificity left to individual job descriptions.

Special Abilities

It is generally agreed that the engineering technician must have the following kinds of special skills and abilities:

1. Proficiency in use of the disciplined and objective scientific method in practical application of the basic principles, concepts, and laws of physics as they comprise the scientific base for the individual's field of technology.

2. Facility with mathematics; ability to use algebra and trigonometry as problem-solving tools in the development and definition of, or to quantify, scientific phenomena or principles; and, when needed, an understanding of - though not necessarily facility in - higher mathematics through analytical geometry and some calculus according to requirements of the technology.

3. A thorough understanding and facility in the use of materials, processes, apparatus, procedures, equipment, methods, and techniques commonly used in the technology.

4. An extensive knowledge of a field of specialization with an understanding of applications of the underlying physical sciences as they relate to the engineering or industrial processes, or research activities that distinguish the technology of the field. The degree of competency and depth of understanding should be sufficient to enable technicians to establish effective rapport with scientists, managers, and engineers with whom they work and to enable them to perform a variety of detailed scientific or technical work as outlined by general procedures or instructions, but requiring individual judgment, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific areas.

5. Communication skills that include the ability to record, analyze, interpret, and transmit facts and ideas with complete objectivity orally, graphically, and in writing.

Activities Performed

Technicians are expected to perform work tasks and/or support to engineers related to any of a combination of the following kinds of activities:

1. Applies knowledge of science and mathematics extensively in rendering direct technical assistance to physical scientists or engineers engaged in scientific research and experimentation.
2. Designs, develops, or plans modifications of new products, procedures, techniques, processes, or applications under supervision of scientific or engineering personnel in applied research, design, and development.
3. Plans, supervises, or assists in installation and inspection of complex scientific apparatus, equipment, and control systems.
4. Advises regarding operation, maintenance, and repair of complex apparatus and equipment with extensive control system.
5. Plans production or operations as a member of the management unit responsible for efficient use of manpower, materials, money, and equipment or apparatus in mass production or routine technical service.
6. Advises, plans, and estimates costs as a field representative of a manufacturer or distributor of technical apparatus, equipment, services, and/or products.
7. Assumes responsibility for performance of tests of mechanical, hydraulic, pneumatic, electrical, or electronic components or systems in the physical sciences; and/or for determinations, tests and/or analyses of substances in the physical and other engineering-related sciences; and prepares appropriate technical reports covering the tests.
8. Prepares or interprets engineering drawings and sketches, or writes detailed scientific specifications or procedures for work related to physical sciences.

9. Selects, compiles, and uses technical information from references such as engineering standards, procedural outlines, and technical digests of research findings.

10. Analyzes and interprets information obtained from precision measuring and recording instruments and/or special procedures and techniques and makes evaluations upon which technical decisions are based.

11. Analyzes and diagnoses technical problems that involve independent decisions. Judgment requires, in addition to technical know-how, substantive experience in the occupational field.

12. Deals with a variety of technical problems involving many factors and variables that require an understanding of applied scientific and technical understanding - the antithesis of narrow specialization.

It is recognized that no two-year technical training program will be sufficient to prepare engineering technicians for all the problems they will encounter in the workplace. The training should however be sufficient to:

1. Provide occupational skills that are compatible with at least entry-level employment in the chosen field.

2. Provide a broad base of knowledge in science, mathematics, and technical subjects that will allow the technician to progress to higher levels of job competence in an environment characterized by rapid change and innovation.

FACULTY AND STAFF

Faculty and staff for a technical education program, particularly one offered in an existing postsecondary vocational institution, should be typified by two things:

1. A baccalaureate-degree-level education in one of the physical sciences, engineering, or a related technology.

2. The overall flexibility to teach a variety of courses including math and physics as well as technical laboratory courses.

To meet accreditation requirements, at least two staff members must be assigned to the Engineering Department on a full-time basis. The majority of the staff must have either a Maters's degree in their field or be Registered Professional Engineers. Additional staff may be obtained from other departments, including general education, math, and other sciences. Teachers in technical courses who are skilled artisans, or journeymen in a particular area should be utilized to teach courses appropriate to their expertise.

It is essential that the staff of an engineering technology department be aware of the interdisciplinary nature of a modern technical training program. Virtually all areas dealt with by technicians involve systems of variouslyarranged electrical, electronic, mechanical, fluidal, thermal, and other physical components. Willingness of the staff to work with persons from other disciplines to develop a comprehensive program is essential. Additionally, the engineering technology staff must demonstrate willingness to form close relationships with practicing engineers, technicians, and other specialists in industries using the technology in question.

The initiative to develop these sorts of relationships is absolutely essential to the exchange of information concerning state-of-the-art equipment and processes necessary to maintain the currency and relevance of the training program.

ACCREDITATION

All institutions in a public school system are obligated to meet standards established by national and regional educational accreditation boards. Of importance to engineering technology programs, however, is credibility with the engineers and specialists with whom the technician must work. A well-recognized agency for programs in engineering technology is the Accreditation Board for Engineering and Technology (ABET), formerly known as the Engineering Council for Professional Development (ECPD). Guidelines for curriculum development, staff, student admission, degrees awarded, nomenclature associated with program graduates, and many other factors are stipulated in ABET standards. Any program seeking to prepare professional technicians should conform to ABET guidelines if it is to be accepted by industry. To do less would be unfair to students and detrimental to the field of engineering technology. All recommendations for program organization in this document are intended to meet or exceed ABET standards. Achievement of ABET accreditation cannot be obtained until a program produces graduates and the graduates are employed for an interval of time.

CURRICULUM ORGANIZATION

The curriculum for training the engineering technician is composed of blocks of courses, each intended to accomplish a specific purpose relative to abilities necessary in the profession. To reiterate, the curriculum must be organized to provide a maximum integration of knowledge, techniques, and manipulative skills. A specific purpose of the curriculum is to provide a cognitive base of information about fundamental concepts, principles, processes, and materials associated with the technology sufficient to allow technicians to learn and acquire new skills in the context of their employment setting throughout their careers.

COURSE GROUPINGS

Basic instructional blocks and their specific purposes are as follows:

1. Basic Sciences and Mathematics

Foundations of all engineering technology programs are in the basic math and physical science areas. The percentage of courses science-to-math and the specific content will vary somewhat with the nature of the specific technology. Courses in mathematics as a general rule begin with college-level algebra and progress through the trigonometric functions and their application to technical problems. A fundamental grasp of the concepts and applications of calculus is also necessary to provide the basis for interpreting and communicating about many technical problems, solutions, and designs. Additionally, modern advances in electronic computer operation applicable to a broad range of technologies have mandated that almost every technician have a facility with the special areas of mathematics related to number systems and logical interpretation utilized in digital electronics and computer programming.

Basic science courses would include physics and/or chemistry courses that support the specified technology. Emphasis should be upon understanding, quantifying, and expressing concepts about basic phenomena of nature as they apply to the technology. Such programs should stress laboratory work and experimentation, observation, and accurate measurement and interpretation as basic quantitative tools in the study and examination of the natural world.

2. Technical Sciences (Core) Courses

Basic technical science, hereinafter referred to as technical core courses, are those technical subjects considered fundamental to a broad area of technology such as electronics, electromechanical, or mechanics. These courses are considered common to the basic understanding of engineering technology and to developing the underlying skills necessary to practice in the field. Basic concepts such as electronics or mechanical fundamentals are covered. More increasingly, microcomputer literacy has become a tool of all technicians and should be included. Another essential area includes the skills necessary for graphical interpretation, representation, and communication of technical concepts, designs, devices, and ideas. Technical core courses are intended to provide technicians with the conceptual instruments of their field and, when combined with practical applications and an understanding of the underlying mathematical and scientific principles, prepare them for more specific training in any of the diverse specializations of modern technology.

3. Technical Specialties

Technical speciality courses focus upon the skills needed in a narrower option of a broader general technology. An example is communication as a specialization in electronics. Technical specialty courses emphasize the methods, procedures, techniques, and hardware of a specific area. Such topics could include design and graphics, construction and fabrication techniques, instrumentation, production methods, field operation, maintenance, testing, and production processes.

An essential area of technical specialization is in the application of standard engineering development procedures to the specified field. A knowledge of applications of science and mathematics to the development of such things as, for example, air conditioning systems, air ducts, electronic circuit development and modification, fluid circuits, plant layout, materials handling and processing, quality assurance and control, and the like are considered mandatory for the engineering technician.

4. Technical Electives

Technical electives serve to support specific career interests of students either to strengthen their basis in fundamentals such as math, science, and computer applications, or to broaden and expand horizons toward future careers by including basics of business, accounting, management, and the like.

5. Communications, Humanities, and Social Sciences

It is essential that the engineering technician be able to effectively communicate with other professionals as well as the general public in an oral and a written fashion. Proficiency in standard grammatical and compositional usages of the English language, including such things as sentence structure, exposition, and spelling and punctuation should be required. Additionally, methods of effective written organization of ideas and clear, concise oral presentations are important in the day-to-day work of the technician.

Humanities and social science courses serve to broaden the perspective of technicians and cause them to work more effectively as members of a technical team. Courses dealing with business organization and socio-economic fundamentals are considered important, as are courses that prepare the technician to deal with the affective and interpersonal situations of the workplace.

MINIMUM CREDIT REQUIREMENTS

A minimum of 100 quarter hours is required for accreditation of engineering technology programs by ABET. Of this total the following breakdown by area should apply:

-Technical Core, Technical Specialty
and Technical Electives
50 quarter hours
-Basic Science and Math
25 quarter hours
-Communication, Humanities, and Social Science
14 quarter hours
-Other Electives and or Local Requirements
quarter hours vary to meet local needs

Remember that these are minimum requirements and may not be sufficient to meet all needs.

CURRICULUM DEVELOPMENT

Currency and relevance in the engineering technology curriculum is critical to program success. Technicians trained inadequately or in outdated programs will quickly prove unproductive in the modern technical environment. The potential for waste of human resources through inadequate curriculum research and development is enormous. The following outline of procedures is considered the minimum investment of time and effort necessary for development of an engineering technology curriculum.

Research

Initial development of an engineering technology program requires that an in-depth analysis of the technology be made. Fortunately, resources are available that greatly facilitate this process. The following areas, though somewhat interrelated, represent major topical divisions of the research process.

1. State of the Art - An analysis of exactly what practices and trends in procedures, processes, techniques, equipment, and so on exist in a given technology is of course critical to curriculum development. Methods of accomplishing a state-of-the-art analysis include (a) literature review, (b) contact with professional and educational organizations, (c) surveys and interviews with related industries, (d) contact with Departments of Labor and Education at the state and federal level. A compilation of a state-of--the-art review can form the foundation for a purpose and mission statement for development of an engineering technology program.

2. Workforce Analysis - Workforce needs for technicians in a given category should be thoroughly assessed in conjunction with the state-of-the-art review. As obvious as this seems, it is often a sorely neglected procedure.

There are at least two sources of workforce information that should be tapped: (1) Workforce forecasting and occupational information available from the U.S. Department of Labor and related state and regional agencies, (2) projection of local industries of need for technical-level employees. These data can and should be collected in conjunction with the state-of-the-art review.

3. Existing Programs - Whenever possible, institutions offering similar technology programs should be contacted for input on existing courses and materials they are employing. There is seldom a need to reinvent the wheel in the matter of curricula and instructional development. Many institutions involved in technical education are forming networks and consortia to routinely share information on new and emerging aspects of the technology.

4. Task Analysis - Design and content of technical specialty courses depends on the nature of the work performed by incumbent technicians in a given field. The only valid method for devleoping a course that teaches the skills, techniques, and abilities required is to conduct a task analysis of each job title for which technicians are trained. The task analysis procedure breaks down or outlines a job into its functional areas, discrete responsibilities, and component steps. The process of task analysis yields data about required skill and competencies of a given job around which instuctional units and courses can be built. Major steps in the task analysis may be outlined as follows:

- Gather task data from existing sources.
- Review text materials for task information
- Compile an occupational inventory that "laundry lists" tentative tasks.
- Interview and observe practicing technicians and their supervisors to validate tasks on issues such as currency, relevance, frequency of performance, criticality, terminology.
- Develop and validate lists of tasks suitable for the type of training situation planned.
- "Detail" tasks by identifying sequential procedural steps involved in each.
- Identify skills and competencies from task detailing information.
- Develop sources that teach skills and competencies identified by task analysis procedures.

Advisory Committee

The key to developing an effective occupational training program in any area is maintaining contact with employers who ultimately will hire the trainees. Thechnical education can no more ignore the concerns of these consumers of the educational product than General Motors can ignore the concerns of the American car buyer.

Advisory committees for curriculum development work should not be developed to serve a public relations function. Contacts between instructors, administrators, and advisory members should occur on a routine basis. Informal as well as formal relationships should be developed. Visitations by school personnel to industry and by industrial personnel to schools should be a common and frequent occurrence. The cost-effectiveness of good technical training is a major concern to educators and industrial mangers alike. Open pathways between educationsl insitutions and the workplace will add immeasurably to the ability of formalized education and training necessary to meet employment requirements vital to the career development of the student population.

MATERIALS DEVELOPMENT

The business of developing materials for technical education programs is a vast and highly sophisticated area. Commerical publishers have expanded millions of dollars in the design and development of technical curricula, and many excellant publishcations are presently available.

Analysis

The intent here is to review cogent points that any instuctor or institution should bear in mind as curriculum materials are either adapted or locally developed. This process should follow the general outline that follows:

1. Examine task analysis and task detailing work carefully.
2. Identify skills and competencies that support asks performed by technicians in the field.
3. Write a topical outline of courses to teach these skills and competencies.
4. Write a course description for each course.
5. Write behavioral student objectives for each course.
6. Write a detailed outline of topics to be covered to accomplish objectives.
7. Specify lab exercises and hands-on task performmances that will support the learning objectives.
8. Review existing commercial materials for adaptation based on their ability to meet course objectives.
9. Develop materials locally to meet specialized needs.

Note that this model defers selection of materials until a thorough analysis of the technician's job role has been made. Good curriculum development does not allow the material to shape programs, but rather utilizes material to meet an assessed and documented need. Thile this may seem a somewhat minor distinction, it is characteristic of training efforts that are concerned about relevance and efficiency.

Technical Core Courses

Technical core courses must be carefully selected so that they cover the fundamental concepts, principles, devices, and processes common to specialization areas within the technology that are to be made available as curriculum options. Technical core courses must be ssen as another building block of knowledge and skills, building upon competencies in math and science, and toward a hands-on ability in dealing with specialized systems. These courses are taught in most institutions already, and the internal development process will be facilitated by the availability of commercial texts and other materials in such areas as basic electronics, graphics and design, mechanical devices and systems, fluid power, and so forth. The key to development of core courses is careful organization of topics into outline form and devleopment of specific student competencies before materials are selected and laboratory experiments are designed. It is toward this sort of specificity in course design that this document is intended.

Technical Specialty Courses

Development of specialty courses in new and emerging technologies such as robotics or telecommunications, to name only two, should not be attempted without a heavy input of technical expertise and advisement. The process of developing materials in thses areas requires that the specialty area be researched in detail and that persons intrinsically familiar with the technology be utilized to select or develop materials that will form course content. It is almost a certainty that the typical education institution must look outside its own doors for experience and expertise to develop course materials for these courses. Currency of materials is always a problem in technology, and the use of state-of-the-art experts is necessary if this currency is to be obtained.

Formatting

Course developed in technical subjects must be flexible to be easily updated as the technology changes. For this reason, a modularized format with each course developed around identified skill or competency blocks is highly desirable. A typical module should consist of the following items:

Introduction - Identifies topics of the module and gives some background rationale for its inclusion into the instructional program.

Module Prerequisites - Identifies knowledge and skills students should possess before studying the module and specifies previous course work relevant to these knowleges and skills.

Objectives - Clearly states what the student should know and be able to do as a result of studying a particular module. These objectives should be stated in behavioral form with an emphasis on student actions that indicate that the learning has in fact taken place.

Subject Matter - Presents background theories and techniques that support the objectives.

Excercises - Provides practical problems to which knowledge gained from study can be applied. Included all out-of-class assignments.

Specialized Learning Activities - Refers student to prior prepared supplemental learning experiences that support module objectives where appropriate. These may consist of such things as audiovisual materials, independent library work, group activities, and the like.

Laboratory Procedures - Presents experiments or "hands-on" acitivities for lab work. Includes step-by-step instuction and identifies necessary instructor check points.

References - Directs the student to sources of supplemental information. Includes print and nonprint media as well as resource persons or agencies.

Test - A criteria-referenced examination that measures achievement against stated objectives.

SECTION III

CURRICULUM DESIGN

This section contains several exhibits that illustrate the organization of the total curriculum, including instructional blocks, specialization course titles, schedules, and course numbers.

Exhibit 1 - Basic instructional areas with breakdown of quarter hours and contact hours.

Exhibit 2 - Three broad areas of technology covered, with specialization options available.

Exhibit 3, 4, and 5 - Itemization of core courses in the three technologies.

Exhibit 6 - Matrix of courses comparing curriculum commonalities.

Exhibit 7, 8, and 9 - Seven-quarter scheduling outline for the three technologies.

Exhibit 10 - A recommended alphanumeric coding system with departmental designations.

EXHIBIT 1
ASSOCIATE DEGREE PROGRAM
ENGINEERING TECHNOLOGY
BASIC CURRICULUM STRUCTURE

	Quarter Hours	Contact Hours
Communications, Humanities, Social Science		
Economics	5	50
Technical Communications	5	50
English and Composition	5	50
Industrial Relations	5	50
	---	---
	20	200
Basic Science and Math		
Phyics	15	270
Math for Engineering Technicians	15	150
	---	---
	30	420
Technical Science Core		
Varies by program		
10 to 12 courses	58 Avg	420 Avg
Technical Specialty Courses		
Varies by program		
5 to 8 courses	30 Avg	250 Avg
Electives		
(Selected as appropriate)		
Varies by program	5-10	50-100
Total	143	1720

EXHIBIT 2
ENGINEERING TECHNOLOGY CURRICULUM
PROGRAM OPTIONS
ASSOCIATE DEGREE PROGRAM

ELECTROMECHANICAL ENGINEERING TECHNOLOGY
- Electrical Technology
- Robotics
- Instrumentation and Industrial Control
- Electromechanical Technology

ELECTRONIC ENGINEERING TECHNOLOGY
- Industrial Electronics
- Computer Applications
- Communications
- Avionics

MECHANICAL ENGINEERING TECHNOLOGY
- Mechanical Technology (Production)
- Mechanical Technology (Design)

EXHIBIT 3

ELECTROMECHANICAL CORE

Options

- Electrical Technology
- Electromechanical Technology
- Instrumentation and Industrial Control
- Robotics

Common Courses	Class	Lab	Credit
*Fundamentals of Engineering Technolgy	3	4	3
*Computer Fundamentals	3	4	5
*Engineering Graphics	1	6	3
*Fundamentals of Electricity and Electronics (DC and AC)	3	4	5
Electronic Devices	3	4	5
*Electromechnical Devices	3	4	5
Electrical Power	2	5	4
Mechanical Devices and Systems	2	2	3
Fluid Power	2	5	4
Instrumentation and Controls	2	4	5
Heating and Cooling Systems	3	4	5
Digital Electronics	3	4	5
Computer Applications	3	4	5

Technical Specialty
    Four courses to be added

*Courses common to three technologies

EXHIBIT 4

ELECTRONICS CORE

Options

- Avionics
- Industrial Electronics
- Computer Applications
- Communications

Common Courses	Class	Lab	Credit
*Fundamentals of Engineering Technology	2	4	3
*Computer Fundamentals	3	4	5
*Engineering Graphics	1	6	3
*Fundamentals of Electricity and Electronics (DC and AC)	3	4	5
Circuit Analysis (DC and AC)	2	6	4
Electronic Devices	3	4	5
*Electromechanical Devices	3	4	5
Electronic Communications	2	5	4
Linear Integrated Circuits	2	5	4
Digital Fundamentals	3	4	5
Computer Applications	3	4	5
Materials and Processes	3	4	5
Two courses to be added			

Technical Specialty
Five courses to be added

*Courses common to three technologies

EXHIBIT 5

MECHANICAL TECHNOLOGY CORE

Options

Mechanical Technology (Production)
Mechanical Technology (Design)

Common Courses	Class	Lab	Credit
*Fundamentals of Engineering Technology	2	4	3
*Computer Fundamentals	3	4	4
*Engineering Graphics	1	6	3
*Fundamentals of Electricity and Electronics (DC and AC)	3	4	5
Manufacturing Processes I	1	6	3
Mechanical Drives	3	4	5
Mechanical Linkages and Machines	2	5	4
*Electromechnaical Devices	3	4	5
Fluid Power	2	5	4
Strength of Materials	3	4	5
Metallurgy	3	4	5
Manufacturing Processes II	3	4	5

Technical Specialty
Five courses to be added

*Courses common to three technologies

EXHIBIT 6
MATRIX OF COURSES COMPARING CURRICULUM COMMONALITIES

	ELT	EMT	MET
COMMUNICATIONS, HUMANITIES, SOCIAL SCIENCES			
Principle of Economics	x	x	x
Industrial Relations	x	x	x
English and Composition	x	x	x
Technical Communications	x	x	x
BASIC SCIENCE AND MATH			
Physics I	x	x	x
Physics II	x	x	x
Physics III	x	x	x
Algebra	x	x	x
Trigonometry	x	x	x
Analytic Geometry and Calculus	x	x	x
TECHNICAL SCIENCE CORE			
Engineering Graphics	x	x	x
Computer Fundamentals	x	x	x
Computer Applications	x	x	
Fundamentals of Electricity and Electronics (DC and AC)	x	x	x
Circuit Analysis	x		
Electrical Power		x	
Electromechanical Devices	x	x	x
Electronic Devices	x	x	
Fluid Power		x	x
Instrumentation and Controls		x	
Mechanical Devices and Systems		x	
Mechanical Drives			x
Mechanical Linkages and Machines			x
Manufacturing Processes I			x
Manufacturing Processes II			x
Metallurgy			x
Strength of Materials			x
Materials and Processes	x		
Electronic Communications	x		
Linear Integrated Circuits	x		
Digital Electronics	x	x	
Heating and Cooling Systems		x	
TECHNICAL SPECIALTY COURSES			
Fundamentals of Engineering Technology	x	x	x
Four to six courses to be added	x	x	x

EXHIBIT 7
ELECTROMECHANICAL TECHNOLOGY
RECOMMENDED CURRICULUM - QUARTER SYSTEM

	Class	Lab	Contact Hours	Cr
First Quarter				
Fundamentals of Engineering Technoloby	2	4	6	3
Computer Fundamentals	3	4	7	5
Algebra	5	0	5	5
English and Composition	5	0	5	5
	--	--	--	--
	15	8	23	18
Second Quarter				
Physics I	3	6	9	5
Trigonometry	5	0	5	5
Fundamentals of Electricity and Electronics (DC and AC)	3	4	7	5
Engineering Graphics	1	6	7	3
	--	--	--	--
	12	16	38	18
Third Quarter				
Electronic Devices	3	4	7	5
Physics II	3	6	9	5
Analytic Geometry and Calculus	5	0	5	5
Mechanical Devices and Systems	2	2	4	3
	--	--	--	--
	13	12	25	18
Fourth Quarter				
Electrical Power and Distribution	2	5	7	4
Fluid Power	2	5	7	4
Physics III	3	6	9	5
Technical Communications	5	0	5	5
	--	--	--	--
	12	16	28	18
Fifth Quarter				
Electromechanical Devices	3	4	7	5
Digital Electronics	3	4	7	5
EMT Specialty Course	2	5	7	4
Principles of Economics	5	0	5	5
	--	--	--	--
	12	13	26	19

Exhibit 7 (Continued)

	Class	Lab	Contact Hours	Cr
Sixth Quarter				
Heating and Cooling Systems	3	4	7	5
EMT Specialty Course	3	5	8	5
Elective	3	0	3	3
EMT Specialty Course	3	4	7	5
	--	--	--	--
	12	13	25	18
Seventh Quarter				
Industrial Relations	5	0	5	5
Instrumentation and Controls	3	4	7	5
Computer Applications	3	4	7	5
EMT Problems Course	0	9	9	3
	--	--	--	--
	11	17	28	18

EXHIBIT 8
ELECTRONICS TECHNOLOGY
RECOMMENDED CURRICULUM - QUARTER SYSTEM

	Class	Lab	Contact Hours	Cr
First Quarter				
Fundamentals of Engineering Technology	2	4	6	3
Computer Fundamentals	3	4	9	5
Algebra	5	0	5	5
English and Composittion	5	0	5	5
	--	--	--	--
	15	8	25	18
Second Quarter				
Physics I	3	6	9	5
Trigonometry	5	0	5	5
Fundamentals of Electricity and Electronics (DC and AC)	3	4	7	5
Engineering Graphics	1	6	7	3
	--	--	--	--
	12	16	28	18
Third Quarter				
Electronic Devices	3	4	7	5
Physics II	3	6	9	5
Analytic Geometry and Calculus	3	0	3	3
Circuit Analysis (DC and AC)	2	6	7	4
	--	--	--	--
	13	16	28	19
Fourth Quarter				
Electronic Communications	2	5	7	4
Linear Integrated Circuits	2	5	7	4
Physics III	3	6	9	5
Technical Communications	5	0	5	5
	--	--	--	--
	12	16	28	18
Fifth Quarter				
Electromechanical Devices	3	4	7	5
Digital Electronics	3	4	7	5
ELT Specialty Course	3	4	7	5
Principles of Economics	5	0	5	5
	--	--	--	--
	13	13	26	19

Exhibit 8 (Continued)

	Class	Lab	Contact Hours	Cr
Sixth Quarter				
ELT Course to be added	3	4	7	5
ELT Specialty Course	3	5	8	5
ELT Course to be added	2	2	4	3
ELT Specialty Course	3	4	7	5
	--	--	--	--
	11	15	26	18
Seventh Quarter				
Industrial Relations	5	0	5	5
Computer Application	3	4	7	5
Materials and Processes	3	4	7	5
ELT Problems Course	0	9	9	3
	--	--	--	--
	11	17	28	18

EXHIBIT 9
MECHANICAL TECHNOLOGY
RECOMMENDED CURRICULUM - QUARTER SYSTEM

	Class	Lab	Contact Hours	Cr
First Quarter				
Fundamentals of Engineering Technology	2	4	6	3
Computer Fundamentals	3	4	7	5
Algebra	5	0	5	5
English and Composition	5	0	5	5
	--	--	--	--
	15	8	23	18
Second Quarter				
Physics I	3	6	9	5
Trigonometry	5	0	5	5
Fundamentals of Electricity and Electronics (DC and AC)	3	4	7	5
Engineering Graphics	1	6	7	3
	--	--	--	--
	12	16	28	18
Third Quarter				
Mechanical Drives	3	4	7	5
Physics II	3	6	9	5
Analytic Geometry and Calculus	5	0	5	5
Manufacturing Processes I	1	6	7	3
	--	--	--	--
	12	16	28	18
Fourth Quarter				
Mechanical Linkages and Machines	2	5	7	4
Fluid Power	2	5	7	4
Physics III	3	6	9	5
Technical Communications	5	0	5	5
	--	--	--	--
	12	16	28	18
Fifth Quarter				
Electromechanical Devices	3	4	7	5
Strength of Materials	3	4	7	5
MT Specialty Course	2	5	7	4
Principles of Economics	5	0	5	5
	--	--	--	--
	13	13	26	19

Exhibit 9 (Continued)

	Class	Lab	Contact Hours	Cr
Sixth Quarter				
MT Specialty Course	3	4	7	5
MT Specialty Course	3	5	8	5
Elective	3	0	3	3
Metallurgy	3	4	7	5
	--	--	--	--
	12	13	25	18
Seventh Quarter				
Industrial Relations	5	0	5	5
MT Specialty Course	3	4	7	5
Manufacturing Processes II	3	4	7	5
MT Problems Course	0	9	9	3
	--	--	--	--
	11	17	28	18

EXHIBIT 10
ENGINEERING TECHNOLOGY CURRICULUM
DEPARTMENTAL DESIGNATIONS

AET	Applied Engineering Technology
ELT	Electronics Engineering Technology
EMT	Electromechanical Engineering Technology
MET	Mechanical Engineering Technology
PHY	Physics
MAT	Math

APPLIED ENGINEERING TECNOLOGY

AET 121	Fundamentals of Engineering Technology
AET 122	English and Composition
AET 123	Computer Fundamentals
AET 221	Technical Communications
AET 222	Principles of Economics
AET 223	Industrial Relations

MATH

MAT 121	Algebra
MAT 122	Trigonometry
MAT 123	Analytic Geometry and Calculus

PHYSICS

PHY 121	Physics I
PHY 122	Physics II
PHY 123	Physics III

ELECTRONICS ENGINEERING TECHNOLOGY

ELT 121	Fundamentals of Electricity and Electronics (DC and AC)
ELT 122	Circuit Analysis
ELT 123	Electronic Devices
ELT 221	Electronic Communications
ELT 222	Linear Integrated Circuits
ELT 223	Digital Electronics
ELT 224	Computer Applications
ELT 225	Materials and Processes
(ELT 300)	Electronics Engineering Technology Specialty courses will be designed by 300-level numbers.

Exhibit 10 (Continued)

ELECTROMECHANICAL ENGINEERING TECHNOLOGY

EMT 121	Mechanical Devices and Systems
EMT 221	Electrical Power and Distribution
EMT 222	Fluid Power
EMT 223	Electromechanical Devices
EMT 224	Heating and Cooling Systems
EMT 225	Instrumentation and Controls
(EMT 300)	Electromechanical Technology specialty courses will be designated by 300-level numbers.

MECHANICAL ENGINEERING TECHNOLOGY

MET 121	Engineering Graphics
MET 122	Mechanical Drives
MET 123	Manufacturing Processes I
MET 221	Mechanical Linkages and Machines
MET 222	Strength of Materials
MET 223	Metallurgy
MET 224	Manufacturing Processes II
(MET 300)	Mechanical Engineering Technology specialty courses will be designated by 300-level numbers.

PROGRAM: Electrical Technology
NAME OF INSTITUTION: Saunders Trade and Technical
High School
183 Palmer Road
Yonkers, New York 10701
(914) 963-4567
CONTACTS: Rocco Lapenta or Joel Rappaport
DEGREE: High School Technical Diploma
YEAR PROGRAM BEGAN: Unknown

Saunders Trade and Technical High School is a public high school in the state of New York. It is under the auspices of the Yonkers Board of Education and provides a self-contained full day. Saunders is a four year high school with 9th, 10th, 11th and 12th grades.

The programs described are in the trade and technical areas. Trade students spend three and three-quarter hours in their specialty area; the remainder of the school day is spent in academic classes. Technical students, some of who are enrolled in the electrical technology program spend approximately two hours daily in their selected area. The remainder of the school day is spent in regents academic classes.

The Electrical Technology program is esentially three years in duration, with the students spending three periods/day in the elected major; one period in theory and two periods laboratory work. In Electrical Technology, seniors are required to take a three year comprehensive examination developed in Albany at the State Education Department (see pp.).

The program is essentially an intense course in electricity and electronics which prepares students both for continuing education in the electronics field and for direct employment at the technician level. A broad background is offered both in theory and in laboratory work. The material covered ranges from the basic structure of matter through current solid-state devices (transistor's, SCR's, LED's, FET's and IC's) and basic digital and communication concepts.

The lab offers opportunities for gaining familiarity with electronic components and circuits, learning troubleshooting techniques, constructing projects and learning to operate industrial-type oscilloscopes, signal generators, power supplies, VTVM's, bridges, etc.

The three year course requirements are listed below. Please note that all 9th grade students explore, for approximately 13 days, each of the 12 curriculums offered at the school. At the end of the 9th grade, they select 3 possible choices for their 10th grade course. One of those choices can be Electrical Technology.

Grade	Subject	# Periods
10	English	1
	Geometry	1
	Gym	1
	Language	1
	Elect Theory I	1
	Elect Lab I	2
	Drafting/Health	1
11	English	1
	Trigonometry	1
	History	1
	Gym/Physics Lab	1
	Physics Theory	1
	Elect Theory II	1
	Elect Lab II	2
12	English	1
	History	1
	Gym	1
	Elect Theory III	1
	Elect Lab III	2
	Elective	1
	Elective	1

Course Title: Electrical Technology Electrical Theory I

Description: This is a course in basic electricity and introduction to electronics. It covers all work related to the 10th year lab course. Much of this course is devoted to electrical theories and concepts of topics such as resistance, current, voltage, magnetism, batteries and electrical circuits. It also covers problem solving of circuits such as Ohms Law and Series and parallel DC and AC circuits.

Methodology: Lecture Problem Solving

Activities/Topics:

Electron Theory
Conductance & Resistance
Electrical Units
Power and Energy
Series Circuits
Parallel Circuits
Primary & Secondary Cells
Magnetism & Electromagnetism
Inductance
Capacitance
DC Motors & Generatore
Characteristics of Sine Waves in AC Circuits
Series A.C. Circuits

Course Materials:
Textbook - Fundamentals of Electrical Circuits by Bell

Evaluation: Exams
Quizes
Homeword
Notebook

Department Grade Weights:
Tests/Quizes 60%
Classwork
Homework/Notebook 40%
Lab Work

Course Title: Electrical Technology Electrical Lab. I

Description: This course is an introduction to electronics. It covers basic electricity by giving students "hands on" experience with experiments ranging from cells, batteries, magnetism and ways of producing electricity to series and parallel DC and AC Circuits. Students will also build printed circuit projects which will give them practical experience in using hand tools and soldering.

Methodology: Lab Experiments
Projects - Designing and Building

Activities/Topics:

Topics Include:

1. Source of Electricity
2. Cells
3. Magnetism & Electromagnetism
4. Switching & Lighting Circuits
5. Relays
6. Series, Parallel and Series Circuits
7. Resistance
8. Inductance
9. Capacitance
10. Motors and Generators

Activities Include:
Use of meters, student development lab trainers, hand tools, soldering equipment in doing experiments and project construction.

Course Materials:
Digiac Experiment Books
Project Manual
Electronic Catalogues
Schematics
Lab Experiment Sheets

Evaluation/Lab Experiments
Exams
Notebook
Classowrk

Department Grade Weights Vary from Marking Period to Marking Period.

Tests	15%
Classwork	
Homework	
Lab Work	85%

Unit I: DC
EL-I

	Recommended Periods
1. Electron Theory	5
1.1 Structure of the Atom	
1.2 Forces within the Atom	
1.3 Charged bodies - Electrostatic Fields	
1.4 Laws of Electrical charges	
2. Conductance, Resistance, Insulation	3
2.1 Conductors	
2.2 Resistors	
2.3 Insulators	
2.4 Semiconductors	
3. Calculation of Resistance, Conductance	6
3.1 Wire sizes	
3.2 Calculation of Resistance	
3.3 Calculation of Conductance	
3.4 Commercial resistors	
4. Electrical Units	8
4.1 Coulombs	
4.2 Potential	
4.3 Current	
4.4 Resistance	
4.5 Ohms Law	
4.6 Prefixes	
5. Commerical Resistors	5
5.1 Types	
5.2 Tolerance	
5.3 Color Code	
5.4 Temperature coefficient	
6. Series Circuits in DC	5
6.1 Series connection	
6.2 Voltage drops	
6.3 Current flow	
6.4 Resistance	

	Recommended Periods
7. Parallel Circuits in DC	6
7.1 Parallel connections	
7.2 Voltage drops	
7.3 Current distribution	
7.4 Special cases	
8. Series-Parallel Circuits	8
8.1 Equivalent resistance	
8.2 Current distribution	
8.3 Voltage distribution	
9. Electrical Power and Energy	5
9.1 Power	
9.2 Wattmeters	
9.3 Power ratings	
9.4 Electrical-mechanical power conversion	
9.5 Efficiency	
9.6 Electrical energy	
9.7 Watt-hour meter	
10. Electric Cells	7
10.1 Primary Cells	
10.2 Dry Cells	
10.3 Voltage Cells in series and parallel	
10.4 Characteristics	
10.5 Secondary Cells	
10.6 Lead Acid	
10.7 Edison Cell	
10.8 Nickel Cadmium Cells	
10.9 Silver Cells	
11. Magnetism	5
11.1 Permanent and temporary magnets	
11.2 Field patterns	
11.3 Magnetic Poles	
11.4 Laws of magnetism	
12. Electromagnetism	7
12.1 Field around current carrying conductor	
12.2 Field around coil	
12.3 Factors influencing strength of field	
12.4 Induction	
12.5 Lenz's Law	
12.6 Magnetic circuit and calculations	
12.7 Magnetization curve	
12.8 Hysteresis and Eddy currents	
12.9 Cores	

	Recommended Periods
13. Relays	1
13.1 Types	
13.2 Applications	
14. Measurements	4
14.1 Meter movements	
14.2 Current - calculation of shunts	
14.3 Voltage - calculation of multipliers	
14.4 Resistance - Series and shunt ohmmeter - ammeter voltameter method	
14.5 Internal meter resistance	
14.6 Power - wattmeter	
14.7 Parallax	
14.8 Accuracy	
15. Capacitance	10
15.1 Dielectrics	
15.2 Capacitance	
15.3 Units	
15.4 Capacitors, series, parallel	
15.5 Time constants, RC circuits	
15.6 Energy in capacitive circuits	
16. Inductance in D.C. Circuits	5
16.1 Induced EMF	
16.2 Self Induction	
16.3 Units	
16.4 Inductors - series parallel	
16.5 Time constants RL circuits	
16.6 Mutual Inductance	
16.7 Energy in Inductive circuits	
17. D.C. Generators	8
17.1 Construction - magnetic and electrical	
17.2 Theory of operation	
17.3 Types of generators	
17.4 Regulation	
18. D.C. Motors	5
18.1 Motor action	
18.2 Fundamental motor equation	
18.3 Types	
18.4 Reversing direction of DC motor	
18.5 Speed control	

	Recommended Periods
19. Overload Protection	1
19.1 Fuses	
19.2 Circuit Breakers	
20. Grounding	1

Unit II: Basic A.C.
EL-I

	Recommended Periods
1. Introduction to A.C.	10
1.1 Sine wave	
a. Generation	
b. Frequency-angular velocity	
c. Terms	
d. Graphical representation	
e. Harmonics	
1.2 Vectors	
1.3 Phase relationships	
2. Introduction to A.C. Circuits	10
2.1 Circuit elements	
a. Resistance	
b. Capacitance	
c. Inductance	
2.2 Capacitive reactance	
2.3 Inductive reactance	
3. Series A.C. Circuits	14
3.1 Impedance	
3.2 Circuit phase angle	
3.3 Power factor	
Vector algebra for A.C. circuits	
3.4 Power	
a. True	
b. Apparent	
c. Reactive	
3.5 Phasor and vector diagrams	
4. Parallel Circuits	10
4.1 Equivalent circuit	
4.2 Impedance	
4.3 Power factor	
4.4 Power	
4.5 Phasor diagrams	
4.6 Resonance	
5. Resonance	8
5.1 Series	
5.2 Parallel	
5.3 Examples	

Recommended Periods

6. Q 4

   6.1 Definition
   6.2 Effects on circuit
   6.3 Band width-calculations

--End Grade Ten--

Course Title: Electrical Technology Electrical Theory - II

Description: Electrical Theory II deals with the basic concepts of alternating circuits, as well as an introduction to basic digital circuits. The course is a continuation of technical electricity 10. It covers basic AC theory including series and parallel reactive circuits, resonance, power systems, transformers, AC machinery, and RC circuits. Digital circuit concepts are introduced with coverage given to number systems, boolean algebra, logic gates, combinational circuits and sequential circuits. Electronic circuits and devices are introduced through coverage of diodes and power supplies.

Methodology: Lecture

Activities/Topics:
Topics Include:

1. Series - parallel circuits
2. Resonance
3. 3 Phase Circuits
4. Transformers
5. RC, L/R Networks
6. Number Theory, Logic Gates
7. Boolean Algebra
8. Combinational Circuits
9. Sequential Circuits

Course Materials:
Texts: Electric Circuits and Machines
Digital Logic Fundamentals

Evaluation:
Tests
Homework
Quizzes
Notebooks

Department Grade Weights:

Tests/Notebook	85%
Homework/Quizzes	15%

Course Title: Electrical Technology Electrical Lab II

Description: The course indroduces students to a wide variety of electronic test equipment, electronic construction techniques, and troubleshooting techniques.

Methodology: Lab Experiments
Project Construction

Activities/Topics:
Topics Include:
AC Circuits, (resonance, reactance, impedance, band width RC, L/R, transformers)
Digital Circuits (logic laws, combinational circuits sequential circuits)

Activities Include:
Use of oscilloscopes, signal generators, power supplies digital trainers. Construction of solid state regulated power supply.

Course Materials:
- Lab Experiment Sheets
- Equipment Information Sheets
- Project Manual
- Manufacturer Equipment Manuals
- Electronic Catalogs

Evaluation:
- Lab Experiments
- Projects
- Lab Work
- Lab Notebook

Department Grade Weights:
Tests 15%
Lab Work 85%

Unit II Basic A.C.

EL-II

Recommended Periods

7. Power Systems 7

    7.1 Basic A.C. power systems
    7.2 Generation of 3 phase
    7.3 Three phase connections
        a. Wye
        b. Delta
    7.4 Three phase power
    7.5 Summary, review

8. Introduction to Transformers 8

    8.1 Introduction to transformers
    8.2 Theory of operation
    8.3 Rating, marking
    8.4 Efficiency
    8.5 Autotransformers
    8.6 Phasing
    8.7 Review, summary

Unit III: Digital Circuits

EL-II

Recommended Periods

1. Number Systems 7

a. Basic concepts

b. Conversions to decimal from base$_R$

c. Conversions to base$_R$ from decimal

d. Miscellaneous conversions

2. Operations With Number Systems 8

a. Operations with binary numbers
    1. Addition
    2. Subtraction
    3. Multiplication
    4. Division
b. Operations in other number systems
c. Subtraction via 1's complements
d. Subtraction via 2's complements
e. Signed numbers in binary systms

3. Logic Gates 7

  a. And gate
  b. Or gate
  c. Inverter
  d. Nand/Nor gates
  e. Enabling gates
  f. Fan out
  g. Alternate device symbols

4. Boolean Algebra 11

   a. Introduction
   b. Boolean operators
   c. Elementary theorems
   d. Laws of algebra
   e. Theorems of boolean algebra
   f. Duality
   g. DeMorgan's Theorems
   h. Boolean expressions
   i. Algebraic simplification

5. Karnaugh Theory 7

   a. Introduction
   b. The technique
   c. Karnaugh simplification using zeroes
   d. Insight into theory of Karnaugh maps
   e. Five variable maps

6. Combinational Logic Circuits 6

   a. Introduction
   b. Implementing Logic Equations with Gates
   c. NAND as a Universal Gate
   d. NOR as a Universal Gate
   e. Conversions to NAND/NOR

7. Digital Codes 2

   a. Binary coded decimal
   b. Gray
   c. Other Binary codes for decimal numbers
   d. Alphanumeric codes
   e. Parity and error detection

8. Basic Concepts for Combinational Circuit Design 2

   a. Introduction
   b. Canonical forms
      Minterms
      Maxterms
   c. Simple Application

9. Combinational Logic Circuit Design and Functions of Combinational Logic Concepts 14

   a. Basic combinational circuit design
   b. Adders
   c. Subtractors
   d. Code converters
   e. Comparators
   f. Decoders, encoders
   g. Multiplexers, demultiplexers
   h. Address decoding
   i. Parity generator and detector

10. Flip Flops

   a. Introduction
   b. Unclocked RS flip flops
   c. Clocked RS FF
   d. D latch
   e. JK FF
   f. Toggle FF
   g. Master slave
   h. Triggering

Unit IV: Advanced AC
EL-II

	Recommended Periods
11. Transformers (Advanced)	4
11.1 Three phase connections	
11.2 Impedance matching	
12. Survey of AC Machines	5
12.1 Three phase	
a. Alternator	
b. Polyphase induction motor	
c. Synchronous motor	
12.2 Single phase motors	
a. Synchronous	
b. Commutator	
c. Induction	
12.3 Power factor correction	
13. Introduction to Circuit Analysis	6
13.1 Current sources	
13.2 Source conversions	
13.3 Mesh analysis	
13.4 Application of Kirchhoff's Laws	
13.5 Determinants	
14. Transient RC, L/R Circuits	7
14.1 Review DC, RC, L/R circuit concepts	
14.2 Charging, discharging	
14.3 Equations	
14.4 Miscellaneous	
a. 555 Timer	
b. Linearity	
15. Introduction to Waveshaping	3
15.1 Differentiating circuits	
15.2 Integrating circuits	
16. Voltmeter Loading	2
16.1 Sensitivity	
16.2 Loading	

Unit V: Basic Electronics

EL:II

	Recommended Periods
1. Basic Atomic Theory	4
1.1 The Bohr atom	
1.2 Excitation	
1.3 Combination of atoms (bonding)	
1.4 Energy level diagram	
1.5 Conductors, Semiconductors, Insulators	
2. Basics of Current Flow	1
2.1 Types of current	
a. Diffusion	
b. Drift	
3. Semiconductor Principles	7
3.1 Bonding	
3.2 Intrinsic Semiconductors	
3.3 Extrinsic Semiconductors	
a. N type	
b. P type	
3.4 PN junction	
3.5 Biasing	
3.6 VI characteristics	
4. Introduction to Power Supplies	2
4.1 Introduction	
4.2 Half wave rectifier	
a. Operation	
b. Characteristics	
c. Waveforms	
d. Equations	
5. Full-Wave Rectifier	2
5.1 Operation	
5.2 Characteristics	
5.3 Waveforsm	
5.4 Equations	
6. Ripple	1

7. Metering with AC-DC	2
7.1 Measurement of DC	
7.2 Measurement of AC rms	
7.3 Measurement of AC peak-peak	
7.4 Measurement of total RMS	
8. Peak Inverse Voltage	1
9. Introduction to Filtering	7
9.1 C-input filter	
a. Operation	
b. Waveforms	
c. Characteristics	
d. Formula	
9.2 RC filter	
a. Voltage divider review	
b. Operation	
c. Characteristics	
9.3 Pi Filter	
a. Operation	
b. Characteristics	
9.4 L input filter	
a. Characteristics	
10. Miscellaneous Power Supply Concepts	1
10.1 Bleeder, voltage divider	
10.2 Regulation	
10.3 Power supply components	
10.4 Specifications	
11. Additional Rectifier Circuits	5
11.1 Full-wave bridge	
11.2 Multiplying circuits	
a. Full-wave doubler	
b. Half-wave doubler	
c. Tripler	
11.3 Industrial circuits	
12. Power Supply Design	5
12.1 Basic consideration	
12.2 Series, parallel connected diodes	
12.3 Design problem 1	
12.4 Design problem 2	
12.5 Design Problem 3	

13. Types of Semiconductor Rectifiers	1
14. Review of Power Supply Circuits	1
15. Zener Diode	4
15.1 Basic concept	
15.2 Circuits	
16. Introduction to Transistors	6
16.1 Basic transistor operation	
16.2 The common-emitter circuit	
16.3 The common-emitter amplifier	
16.4 Relationship between Alpha and Beta	
17. Load Line Operation	6
17.1 Load line concept	
17.2 DC load line	
17.3 AC load line	

--End Grade Eleven--

Course Title: Electrical Technology Electrical Theory III

Description: Electrical Theory III introduces the student to a wide variety of solid state devices, circuits, and principles. Theory of operation of diodes, silicon controlled rectifiers, diacs, triacs, transitors, light emitting diodes are introduced. Power supplies, amplifers, control circuits, operational amplifiers, timers are among the many circuits covered.

Methodology: Lecture

Activities/Topics:

Topics Include:

1. Diodes, Transistors, Fet's, Scr's, Triacs, Linear IC's, LED's
2. Power supplies, Amplifiers, oscillators
3. Negative feedback, regulation
4. Communication circuits

Activities Include:

1. Trips to electronic manufacturing and engineering facilities
2. Trips to electronic equipment shows

Course Materials:

Texts - Electronic Principles

Evaluation:

Tests
Homework
Quizzes
Notebook

Department Grade Weights:

Tests/Notebooks: 85%
Homework: 15%

Course Title: Electrical Technology Electronics Lab III

Description: Offers student opportunity to become familiar with advanced electronic tests equipment (curve tracer, capacitance tester, transistor tester, strobotac, etc.). Also introduces some basic design experiences with transistors, power supplies, amplifiers, etc. Opportunities are also offered for some test equipment calibration and repair.

Methodology: Lab Experiments
Projects

Activities/Topics:
Topics Include:
Power Supplies, Amplifiers, SCR Circuits,
Digital Circuits

Activities Include:
Project Construction
Experiment Calibration Repair

Course Materials:
Lab Experiment Sheets
Industrial Equipment Manuals
Industrial Catalogs

Evaluation:
Lab Experiments
Projects
Lab Work
Lab Notebook

Department Grade Weights:
Tests/Classwork: 10%
Homework/Lab Work/Reports: 90%

Unit V: Basic Electronics (cont'd)
EL-III

	Recommended Periods
18. Characteristic Curves (CE)	3
18.1 Significance	
18.2 Graphical calculation of Parameters	
18.3 Regions of operations	
a. Active	
b. Cutoff	
c. Saturation	
19. Biasing	3
19.1 Transistor bias circuits	
a. Fixed	
b. Self	
c. Voltage divider	
20. Stabilization	3
20.1 Effects of temperature on operation	
20.2 Concept of stabilization	
20.3 Stabilizing circuits	
21. Transistor Small Signal Amplifiers (CE)	6
21.1 General considerations	
21.2 Concept of gain	
21.3 Concept of frequency response	
21.4 Cascade amplifiers	
a. RC	
b. Transformer	
c. Direct	
22. Emitter Follower	3
22.1 Basic operation	
22.2 Characteristics	
23. Common Base	3
23.1 Basic operation	
23.2 Characteristics	
23.3 Summary of features of CE, CB, CC Type Circuits	

24. Transistor Equivalent Circuits	4
24.1 Hybrid equivalent circuit (CE)	
24.2 Review Thevenin, Norton Theorems	
24.3 Midband calculations involving Ai, Av, Ap, Zin, Zout	
25. Special Amplifiers	5
25.1 Complementary symmetry	
25.2 Darlington pair	
25.3 Differential amplifier	
25.4 Common mode rejection ratio	
26. Power Amplifiers	5
26.1 Classes of amplifiers	
26.2 Single-ended	
26.3 Push-pul	
a. Phase inverter	
b. Class A push-pull	
c. Class B push-pull	
d. Complementary symmetry	
27. Negative Feedback	3
27.1 Features	
27.2 Types	
27.3 Calculations	
28. Decibels	2
29. Field Effect Transistors	14
29.1 Basic operation, JFET	
29.2 Transfer characteristics	
29.3 Parameters	
29.4 Gain calculations	
29.5 Load line analysis	
29.6 Equivalent circuit	
29.7 Mosfet	
a. Depletion-type	
b. Enhancement-type	
c. Use in digital circuits	
29.8 FET as a voltage controlled resister	

30. Power Control Circuits 9

- 30.1 Introduction to Silicon Controlled Rectifiers
  - a. Basic operation
  - b. Simple power control circuits
  - c. Triggering
    - 1. Resistive
    - 2. RC
    - 3. Bridge
  - d. Circuits
- 30.2 Unijunction transistor
  - a. Basic operation
  - b. Characteristics
  - c. Circuits

31. Introduction to Photo Electricity 6

- 31.1 Concepts of Light
- 31.2 Photoconductive Cell
  - a. Concepts
  - b. Circuits
- 31.3 Photo diode
- 31.4 Solar cell
- 31.5 Light emitting diodes
- 31.6 Liquid crystal displays
- 31.7 Optoelectronic couplers
- 31.8 Circuits

32. Regulated Power Supplies 4

- 32.1 Design Zener Shunt regulated supplies
- 32.2 Series transistor regulated supply
- 32.3 Solid State regulators
  - a. Fixed
  - b. Adjustable

33. I C Operational Amplifiers 12

- 33.1 Introduction
- 33.2 Comparators
- 33.3 Inverting, non-inverting amplifiers
- 33.4 Miscellaneous applications
  - a. Integrators
  - b. Differentiators
  - c. Active filters
  - d. Signal generation

34. I C Timers 3

- 34.1 Introduction
- 34.2 Astable multivibrators
- 34.3 Monostable multivibrators
- 34.4 Miscellaneous applications

35. Network Theorem/Circuit Analysis 5

- 35.1 Thevenin's Theorem
- 35.2 Norton's Theorem
- 35.3 Superposition
- 35.4 Nodal analysis
- 35.3 Kirchhoff's Laws

36. Miscellaneous Devices 2

- 36.1 Tunnel diodes
- 36.2 Themistor
- 36.3 Crystals
- 36.4 Voltage variable capacitor diodes
- 36.5 Vacuum tubes

Unit VI: Advanced Electronics
EL-III

Recommended Periods

37. Oscillators 3

- 37.1 Basic concepts
- 37.2 Types

38. Communication Circuits 13

- 38.1 Mixing
- 38.2 Detection
- 38.3 Tuned amplifiers
- 38.4 Transmission
- 38.5 Modulation, AM
- 38.6 Modulation, FM
- 38.7 Superheterodyne receiver

Unit VII Advanced Digital Circuits

EL-III

39. Introduction to Sequential Circuits	5

- a. Introduction
- b. State Diagrams
- c. State tables

40. Counters	10

- a. Introduction
- b. Asynchronous (Ripple) counters
- c. Mod N counters
- d. Analysis of sequential circuits
- e. Synchronous counter design

41. Resisters	3

- a. Storage concept of registers
- b. Types of registers

42. Arithmetic Logic	10

- a. Addition
- b. Subtraction
- c. Signed numbers
- d. Serial binary adder
- e. Parallel binary adder
- f. Multiplication/division

43. Miscellaneous Digital Circuits and Associated Topics	6

- a. The one shot
- b. Astable multivibrator
- c. Schmitt trigger
- d. Digital to Analog conversion
- e. Analog to digital conversion

44. Digital Integrated Circuits 4

   a. I C construction
   b. SSI, MSI, LSI
   c. Logic families, RTL, DTL, TTL, ECL, I^2L, MOS, CMOS, PMOS, NMOS

45. Introduction to Microprocessors and Computer Organization 25

   a. Basic computer architecture
   b. Basic computer operation

--End Grade Twelve--

The University of the State of New York

THE STATE EDUCATION DEPARTMENT

COMPREHENSIVE EXAMINATION IN TECHNICAL ELECTRICITY AND ELECTRONICS

Wednesday, June 22, 1983 — 9:15 a.m. to 12:15 p.m., only

This examination counts 100 credits. It must be completed in 3 hours.

Use of a slide rule or cordless electric calculator and of the natural and logarithmic trigonometric tables will be allowed.

The last page of the booklet is the Part I answer sheet. Fold the last page along the perforations and then, slowly and carefully, tear off the answer sheet.

Fill in the heading of your answer sheet.

The answers to all questions in Part I are to be written on the answer sheet. Parts II and III are to be answered on paper provided by the school.

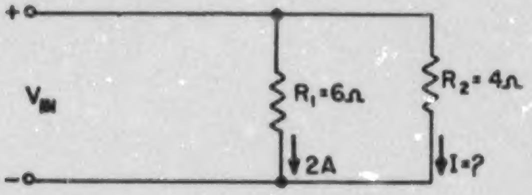
Now open the test booklet, read the directions at the top of the first page, and begin work.

Part I

Answer 34 of the 38 questions in this group.

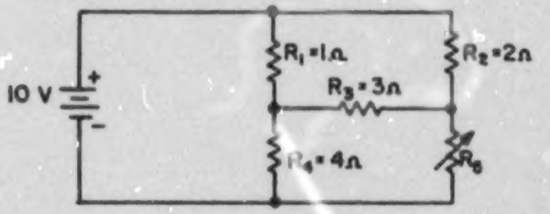
Directions (1–38): Each question is followed by four choices. Decide which choice is the best answer. Then, in the appropriate space provided on the answer sheet, write the *number* of the best answer. [51]

1 What is the current through R_2 in the circuit diagram shown below?



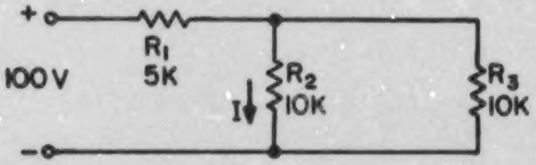
(1) 1.3 A
(2) 2.4 A
(3) 3.0 A
(4) 7.0 A

2 In the circuit diagram below, what must be the value of the resistance of resistor R_5 to have the current through R_3 equal to zero?



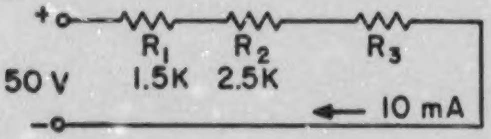
(1) 1.0 Ω
(2) 2.0 Ω
(3) 8.0 Ω
(4) 4.0 Ω

3 What is the current value through R_2 in the circuit diagram shown below?



(1) 5 mA
(2) 10 mA
(3) 5 A
(4) 10 A

4 What is the value of R_3 in the circuit diagram shown below?

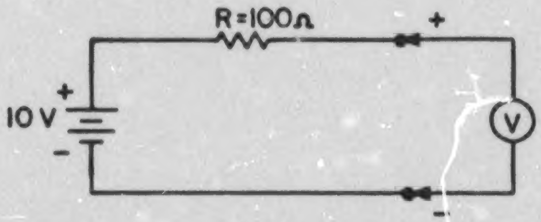


(1) 5 Ω
(2) 500 Ω
(3) 1,000 Ω
(4) 5,000 Ω

5 The resistance of a copper wire increases as the temperature

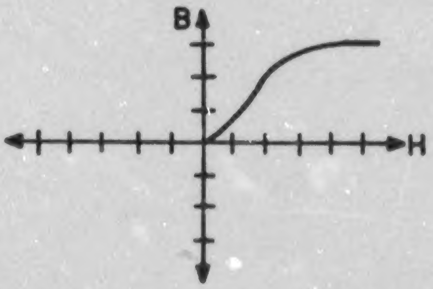
1 decreases
2 increases
3 remains the same
4 drops to zero

6 In the circuit diagram shown below, what should the DVM or VTVM read?



(1) 0 V
(2) 0.1 V
(3) 5 V
(4) 10 V

7 A *B-H* curve for a material is shown below. For increasing values of *H*, the shape of the curve begins to approach a straight horizontal line. Which of the following factors causes this phenomenon to occur?



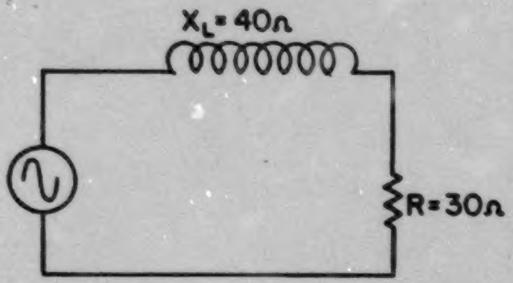
1 saturation
2 reluctance
3 coercive force
4 residual magnetism

8 A glowing lamp and an iron-core coil are connected in series across a 120-volt, 60-hertz supply. If the iron core is removed from the coil, the lamp will

1 become dimmer but remain lit
2 become brighter
3 remain at the same brightness
4 be extinguished or off

9 Magnetomotive force of a coil can be increased by increasing the
1 distance between coil turns
2 cross-sectional area of the coil
3 permeability of the core material
4 current through the coil

10 What is the reactance in the circuit diagram shown below?



(1) 30 Ω
(2) 40 Ω
(3) 50 Ω
(4) 70 Ω

11 A resistor and an inductor are connected in series across a variable-frequency signal source. As the frequency of the input source is increased, the power factor will
1 approach unity
2 approach zero
3 approach infinity
4 remain unchanged

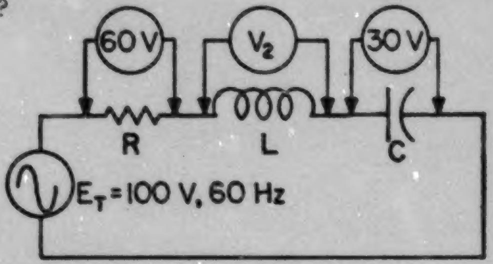
12 Frequency always equals the
1 period
2 peak-to-peak value
3 number of cycles multiplied by corresponding time
4 number of cycles divided by corresponding time

13 An AC voltmeter indicates 10 V_{rms}. On the oscilloscope, the same sine wave would have a peak-to-peak voltage of
(1) 7.1 V
(2) 10.0 V
(3) 14.2 V
(4) 28.3 V

14 In a single-phase AC circuit, the circuit capacitance is doubled. The circuit capacitive reactance will be
1 halved
2 doubled
3 tripled
4 quadrupled

15 One cycle of a sine wave observed on an oscilloscope occupies 4 centimeters in the horizontal direction and 5 centimeters in the vertical direction. If the time base calibration is 400 microseconds per centimeter, the frequency of the sine wave is
(1) 400 Hz
(2) 500 Hz
(3) 625 Hz
(4) 1,250 Hz

16 If the series RLC circuit shown below has a lagging power factor, what will be the reading of voltmeter V_2?



(1) 10 V
(2) 50 V
(3) 80 V
(4) 110 V

17 A load receives 1 ampere DC from an unfiltered half-wave rectifier. What is the average current through the diode?
(1) 1.0 A
(2) 0.63 A
(3) 1.4 A
(4) 2.8 A

18 A half-wave rectifier is supplied from a 120-volt, 60-hertz line. What will be the ripple frequency of the output?
(1) 15 Hz
(2) 30 Hz
(3) 60 Hz
(4) 120 Hz

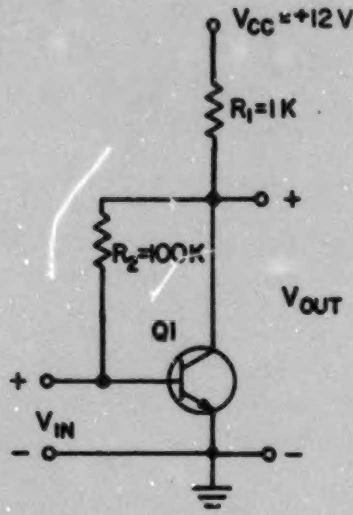
19 The condition of a filter capacitor, connected across the output of a rectifier circuit, may be tested by using an oscilloscope to measure the
1 peak-to-peak voltage at the input
2 forward voltage drop across the diode
3 peak-to-peak ripple at the output
4 ripple frequency at the output

20 Which amplifier configuration may have a direct connection from the collector terminal of a transistor to the DC voltage source (V_{cc})?
1 common emitter
2 common collector (emitter follower)
3 common base
4 collector follower

21 A bypass capacitor placed across the emitter resistor in a common-emitter amplifier is used to
1 reduce voltage gain
2 stabilize the amplifier's temperature
3 bypass the DC to ground
4 restore the voltage gain

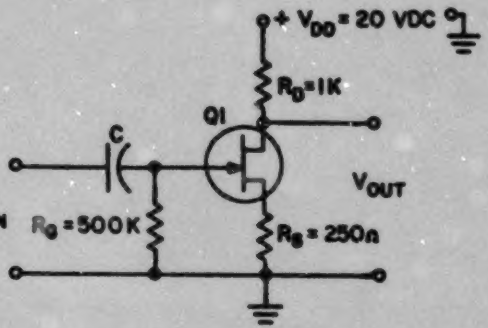
22 Which FET amplifier configuration will invert the voltage signal between its input and output terminals?
1 common source
2 common drain
3 common gate
4 source follower

23 The transistor amplifier circuit diagram shown below uses which type of biasing method?



1 fixed
2 voltage feedback (self-bias)
3 current feedback
4 beta independent (voltage divider)

24 In the circuit diagram shown below, if I_D is 5 milliamps, what is the voltage of V_{GS}?



(1) -1.25 V
(2) 0 V
(3) 1.25 V
(4) 10 V

25 Which bipolar transistor configuration provides the highest power gain?

1 common base
2 common collector
3 common emitter
4 emitter follower

26 A 100-volt DC supply is connected across a 2-megohm resistor in series with a 4.0 MFD (μF) capacitor. What is the approximate charging current at two time constants?

(1) 7.0 μA
(2) 18.5 μA
(3) 43.0 μA
(4) 50.0 μA

27 A power supply delivers 24 volts at its rated load. When the load is removed, the voltage increases to 30 volts. What is the percentage of voltage regulation?

(1) 20%
(2) 25%
(3) 75%
(4) 80%

28 A 741 operational amplifier (OPAMP) has an open loop voltage gain of 100,000. If 10% negative feedback is introduced, the new gain will be approximately

(1) 1
(2) 10
(3) 100
(4) 10,000

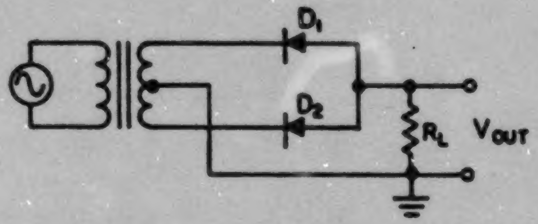
29 An amplifier system has an absolute gain of 20 at the -3 decibel power point. The midfrequency voltage gain should be approximately

(1) 60
(2) 40
(3) 28.3
(4) 10

30 A 100-volt RMS sine wave is applied to a full-wave doubler circuit. Assuming an ideal capacitor and no load, what is the approximate value of the DC output voltage?

(1) 141 V
(2) 200 V
(3) 283 V
(4) 314 V

31 In the circuit diagram shown below, what would be the result if diode D_1 opened?



1 The ripple frequency would double.
2 The DC output voltage would stay the same.
3 The PIV of diode D_2 would double.
4 The DC load current would be halved.

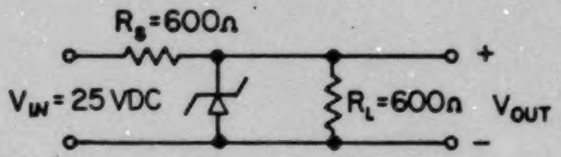
32 A capacitor filter used in a power supply could be classified as a

1 low-pass filter
2 band-pass filter
3 high-pass filter
4 band-rejection filter

33 A coupling capacitor in an RC-coupled voltage amplifier is used to

1 block AC voltage
2 reduce midband frequency voltage gain
3 reduce high frequency voltage gain
4 block DC voltage

34 In the circuit diagram below, what is the current through the Zener diode if $V_z = 10$ V?



(1) 8 mA
(2) 17 mA
(3) 25 mA
(4) 50 mA

35 The logic circuit combination of an OR gate followed by an inverter is equivalent to

1 an exclusive OR
2 a NAND gate
3 a NOR gate
4 a latch

36 The type of computer memory that requires periodic refreshing is

(1) static RAM
(2) dynamic RAM
(3) ROM
(4) PROM

37 How many flip-flops would be required to construct a MOD 16 binary ripple counter?

(1) 8
(2) 2
(3) 16
(4) 4

38 The "555" chip is normally used as a

1 monostable or astable multivibrator
2 three-terminal voltage regulator
3 shift register
4 seven-segment decoder

DIRECTIONS: Parts II and III

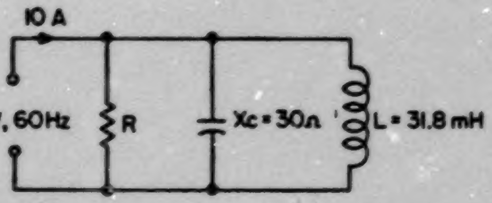
You must answer a total of seven questions from Parts II and III combined. You must answer three questions from each part and, at your option, one additional question from either Part II or III.

Answers to the questions chosen from Part II are to be placed on paper provided by the school.

Part II

Answer at least three questions from this part (39–44). Each question counts 7 credits. Be sure to answer every part of the questions you choose. [If you choose to answer a fourth question from this part, answer only three questions from Part III.]

39 Base your answers to parts *a* through *d* on the circuit diagram shown below. The total circuit current is 10 amperes.

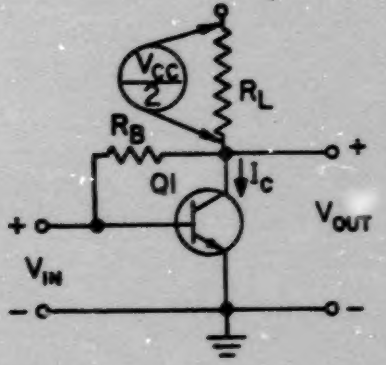


Determine the:

a value of resistor *R* [2]
b value of capacitance *C* [1]
c circuit power factor [2]
d circuit true power [2]

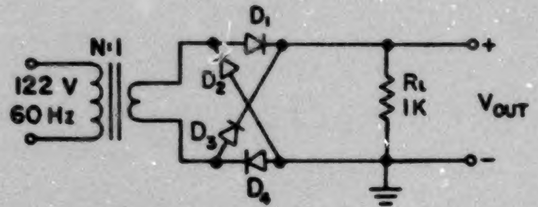
40 Base your answers to parts *a* through g on the information and circuit diagram below. Assume a silicon transistor is used and I_{co} leakage is ignored. [7]

$I_C = 4$ mA, $h_{FE} = 24$, $V_{RL} = \frac{V_{cc}}{2}$ and $V_{cc} = 9.4$ V.



Determine:
a V_{CE}
b I_{RL}
c R_L
d V_{BE}
e I_B
f V_{RB}
g R_B

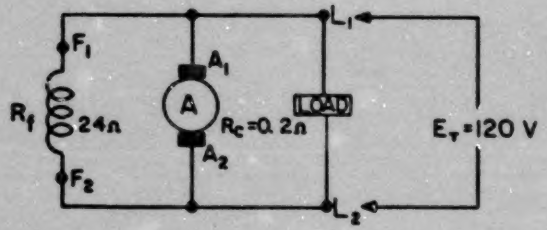
41 Base your answers to *a* through *d* on the circuit diagram shown below. Assume ideal diodes.



Determine the:

a turns ratio to obtain a DC output of 22 volts [3]
b PIV per diode [1]
c average current through each diode [1]
d DC voltage output if one of the diodes opens [2]

42 Base your answers to parts *a* through *d* on the circuit diagram of the DC shunt generator shown below. The power output is 2.4 kW, the load voltage is 120 volts, and the stray power losses are 175 watts.

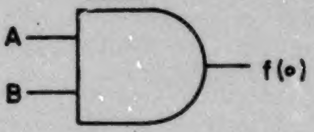


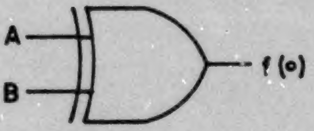
Determine the:

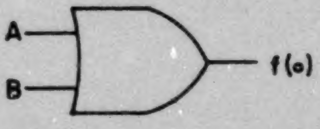
a armature current [2]
b total copper losses [2]
c voltage induced into the armature [2]
d generator's efficiency [1]

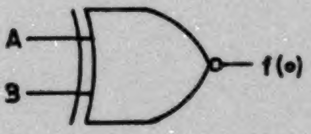
43 For *each* logic gate symbol listed in *a* through *g*, write on the paper provided by the school the *number* of the truth table, *chosen from the truth tables shown below*, that best represents its output. [A truth table may be used for more than one logic gate.] [7]

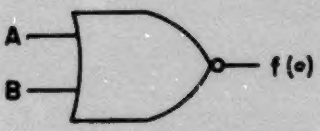
Gates

a


b


c


d


e


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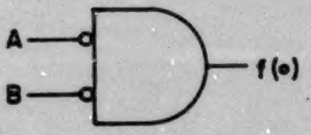
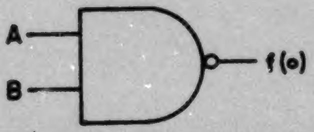


g


Truth Tables

(1)

A	B	f(o)
0	0	0
0	1	1
1	0	1
1	1	1

(2)

A	B	f(o)
0	0	1
0	1	0
1	0	0
1	1	1

(3)

A	B	f(o)
0	0	1
0	1	1
1	0	1
1	1	0

(4)

A	B	f(o)
0	0	0
0	1	0
1	0	0
1	1	1

(5)

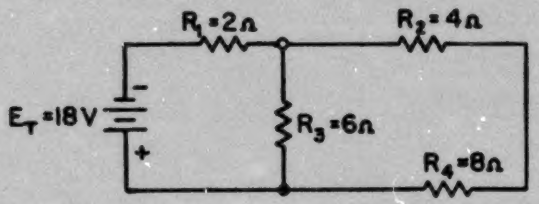
A	B	f(o)
0	0	0
0	1	1
1	0	1
1	1	0

(6)

A	B	f(o)
0	0	1
0	1	0
1	0	0
1	1	0

---

44 Base your answers to parts *a* through *d* on the circuit diagram shown below.



Determine the:

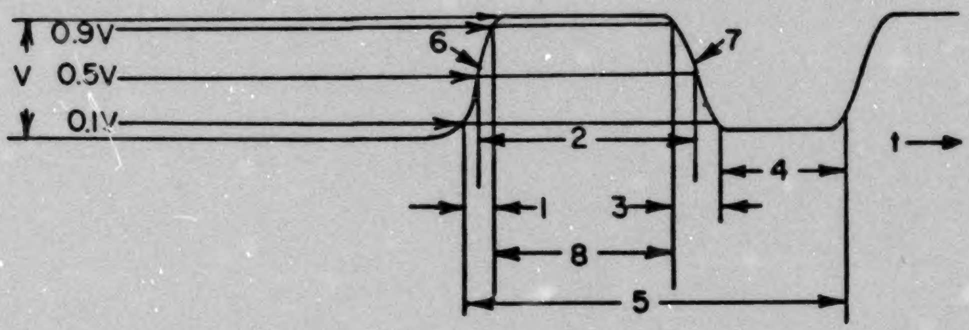
a power delivered by the battery [2]
b voltage drop across resistor R_4 [2]
c current through resistor R_3 [2]
d total circuit current if resistor R_2 opens [1]

Answers to the questions chosen from Part III are to be placed on paper provided by the school.

Part III

Answer at least three questions from this part (45–53). Each question counts 7 credits. Be sure to answer every part of the questions you choose. [If you did not choose to answer a fourth question from Part II, you must select a fourth question from this part to complete a total of seven questions from Parts II and III.]

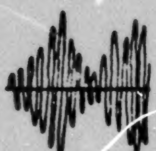
45 For *each* part listed in *a* through g, write on the paper provided by the school the *number* which identifies that part in the diagram. [7]

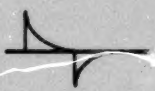


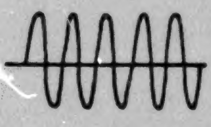
Parts

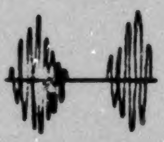
- *a* Leading edge
- *b* Fall time
- *c* Trailing edge
- *d* Pulse width
- *e* Rise time
- *f* Resting time
- *g* Pulse repetition time

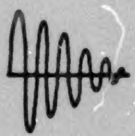
46 For each wave or pulse listed in *a* through g, write on the paper provided by the school the *number* of the diagram, *chosen from the diagrams below*, that best fits that wave or pulse. [7]

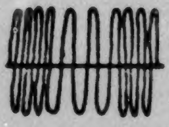

(1)

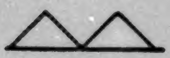

(2)


(3)


(4)


(5)

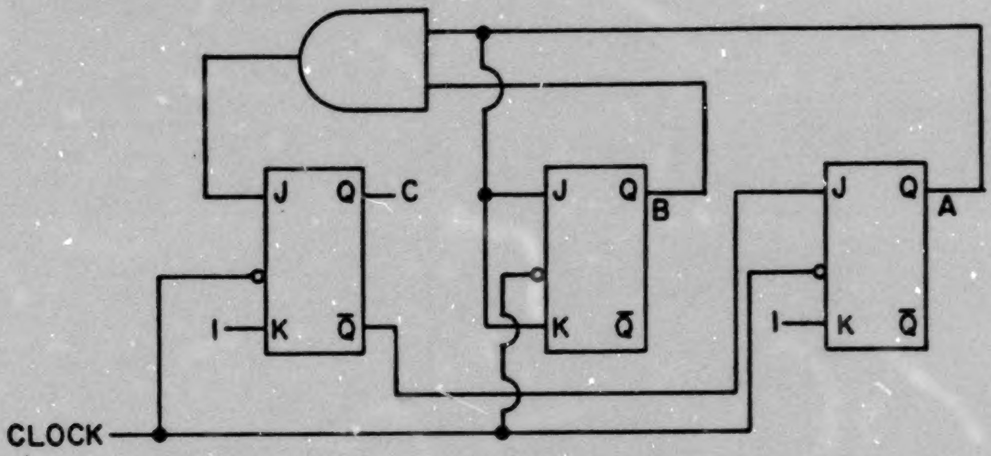

(6)


(7)

Waves or Pulses

- *a* Continuous wave
- *b* Damped wave
- *c* AM wave, percent modulation less than 100%
- *d* Differentiated wave
- *e* Integrated wave
- *f* Overmodulated wave
- *g* Frequency modulated wave

47 Base your answers to parts *a* through *e* on the digital circuit shown below which is completely reset prior to the application of the first clock pulse.



a What binary information is stored in this device prior to the first clock pulse? [1]
b What binary information is stored after the first clock pulse, but before the second? [2]
c Do these devices change state on the positive-going or negative-going edge of the clock pulse? [1]
d How many clock pulses are needed to cycle this device from 000 back to 000? [2]
e What function is performed by this circuit? [1]

---

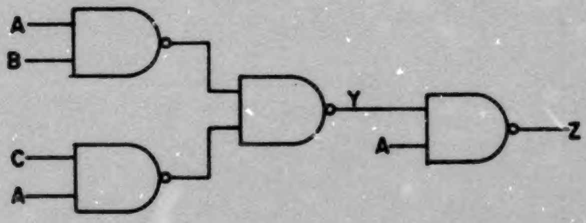
48 Base your answers to parts *a* through *d* on the information below.

A parallel resonant circuit consists of a coil having an inductance of 0.20 mH and resistance of 62.5 ohms connected in parallel with a 130-pF capacitor. This combination is connected to a voltage source of 100 mV.

Determine the:

a resonant frequency [2]
b circuit bandwidth [2]
c total circuit current [2]
d current through the inductor [1]

49 Base your answers to parts *a* through *d* on the logic diagram shown below.



a Write the logic expression for output *Y* and for output Z. [2]
b Obtain the simplest expression for Z. [2]
c Complete a logic truth table for Z. [2]
d Draw a logic diagram for the simplest expression, using AND, OR, and inverters. [1]

50 The following are data from a test of a 3-kVA, 240-V/120-V, 60-Hz, single-phase transformer operating at a power factor of 0.9.

Resistance of 120-volt winding: 0.12 ohm
Resistance of 240-volt winding: 0.32 ohm
Core losses: 100 watts

At rated kVA and 90% power factor, determine the:

a P_{out} [1]
b I_{pri} and I_{sec} [2]
c total copper losses [2]
d efficiency [2]

51 Base your answers to parts *a* through g on the information below. [7]

A wye-connected, 6-pole alternator with an efficiency of 90% at rated load supplies a delta-connected resistive load. Each phase of the load has pure resistance of 10 ohms. Each phase of the alternator produces 100 volts at 65 hertz, and the load provides a unity power factor.

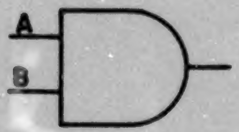
Determine the:

a line voltage
b line current
c total power delivered to the load
d power delivered by the prime mover, in watts
e power delivered by the prime mover, in horsepower
f phase current of the load
g speed of the prime mover

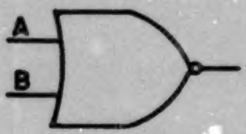
52 Draw the Karnaugh map for each of the logic gates shown below. [7]

Gates

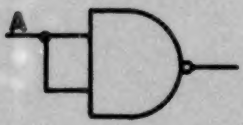
a



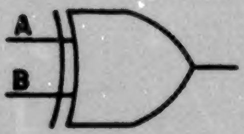
b



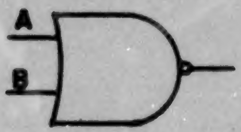
c



d



e



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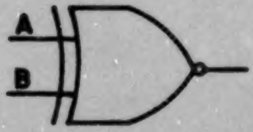
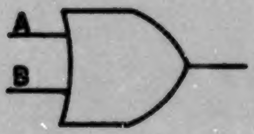


g



53 Each phase of a three-phase, delta-connected alternator supplies 100 amperes at 250 volts to a three-phase impedance load with a power factor of 0.7 lagging.

Determine the:

a value of E_{line} at the load [2]
b value of I_{line} delivered to the load [2]
c total KVA of the alternator [1]
d total power delivered to the load, in watts [2]

COMPREHENSIVE EXAMINATION IN TECHNICAL ELECTRICITY AND ELECTRONICS

Wednesday, June 22, 1983 — 9:15 a.m. to 12:15 p.m., only

ANSWER SHEET

Pupil ....

School ....

Your answers to 34 of the 38 questions from Part I should be written on this answer sheet. After you have answered the required 34 questions, place an X to the right of the four questions you choose not to answer.

1..........
2..........
3..........
4..........
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34..........
35..........
36..........
37..........
38..........

No. Right...............

Place your answers to the remaining questions on this examination on paper provided by the school.

FOR TEACHER USE ONLY

Credits

Part I ....
(Use table below)

Part II ....

Part III ....

Total ....

Rater's Initials: ....

PART I CREDITS

Directions to Teacher:

In the table below, draw a circle around the number of right answers and the adjacent number of credits. Then write the number of credits (not the number right) in the space provided above.

No. Right	Credits	No. Right	Credits
34	51	17	26
33	50	16	24
32	48	15	23
31	47	14	21
30	45	13	20
29	44	12	18
28	42	11	17
27	41	10	15
26	39	9	14
25	38	8	12
24	36	7	11
23	35	6	9
22	33	5	8
21	32	4	6
20	30	3	5
19	29	2	3
18	27	1	2
		0	0

Equipment

The major test equipment and electronic trainers includes:

Test Equipment
1. Tektronix - Oscilloscopes
2. Hewlett Packard - VTVM's, Signal Sources, Power Supplies
3. B and K - Oscilloscopes
4. Triplett, Simpson - DMM's, VOM's, VTVM's
5. Lambda - Power Supplies

Trainers
1. Digiac Corporation - Digital Trainers, model 3010KD
2. E and L Instruments - OP-amp Trainers (OA-2), Digi-Designers (DD-1), Microprocessor Trainer (MMD-1)
3. Currently examining two microprocessor trainers Heathkit ET 3400A and E and L MTP 80
4. Digiac Corporation SDL (Student Development Lab by ETS) including Degiac T251 Regulated PS, Digiac T252 Variable AC Supply, Digiac Dual Impedance Loudspeaker

Other recommendations include a close look at the wide variety of material offered by Heathkit. It is well developed and accompanied by courseware of good quality. Furthermore, the Heathkit Continuing Education series is excellent for staff upgrading.

Faculty Development

Last year the school supported a course on computer programming for all faculty members. Sabbaticals have also been provided to the faculty for taking engineering courses. In general, however, the faculty are responsible for taking courses at their own expense. Two instructors teach the electronics courses.

Placement

Normally 80-90% of the technical students go onto further education at the Community College or College level. Students are prepared for admission to engineering schools for advanced study. Among the schools attended are Cornell, Pratt, MIT and Manhattan. Advanced standing is accorded a the local community college, Westchester Community College. The courses are also at the technician level. If they do not enroll in college, students generally enter employment as technicians in manufacturing, power and communications industries where they obtain positions as laboratory technicians, engineering aids, draftsmen, inspectors, servicemen,and salesmen of technical products.

PROGRAM: Software Engineering Technician
INSTITUTION: Spokane Falls Community College
W3410 Fort George Wright Drive
Spokane, Washington 99204
(509) 459-3500
CONTACT: Paul Lecoq or Edwin Hill
DEGREE: Associate of Applied Science Degree or Certificate for those with previous related degree
DATE BEGAN: 1979

History

The curriculum was developed from a microprocessor programmer's curriculum. When a curriculum was needed to train students as software engineering technicians, it was found that in addition to the more traditional programming skills needed that they also needed:

1) an overall background in electronics,
2) communication skills in writing, speaking, and listening, and
3) a project oriented curriculum.

A curriculum was written by Paul Lecoq who is currently the instructor of the program. He submitted his plans to the district committees. The program started in 1979.

The Program

The curriculum is an intensive program which prepares graduates to program micro and mini-computer systems. Enough electronics is included to allow graduates to work well with engineers and technicians, however the main focus is on quality structures and well-documented software. The program goals are:

1. Program small computers for scientific and business applications.
2. Understand the basic elements of digital and linear integrated electronics.
3. Document small computer systems completely, in addition to communicating well with software and hardware specialists.
4. Understand software and hardware interfacing between microprocessors and peripheral devices.
5. Program in assembly language, BASIC or PASCAL, and FORTRAN or COBOL.
6. Apply the elements of accounting and mathematics required for programming microprocessors in business and industry.
7. Understand the operation of a variety of microprocessors.
8. Utilize microprocessor components in developing industrial, business and process control systems.

The course of study follows.

Associate of Applied Science Degree Program

Freshman Year

Fall Quarter:	Credits
DPCS 160 101 Technical Introduction to Data Processing	5
DPCS 160 Intro to Microprocessors	3
DPCS 251 BASIC Language or PASCAL	2
MATH 111 Pre-Calculus	5
PHYS 100 Introductory Physics	5
	--
Total	20

Winter Quarter:	Credits
DPCS 161 Electronics Survey & Lab	5
DPCS 231 COBOL Language* or	
DPCS 241 Intro to FORTRAN Language*	5
GBUS 101 Intro to Business	5
MATH 112 Pre-Calculus	5
	--
Total	20

Spring Quarter:	Credits
DPCS 162 Electronic Circuits	5
DPCS 171 Microprocessor Assembly Language Programming	5
ENG 101 English Composition or	
ENG 105 Technical Writing	5
Approved Elective	5
	--
Total	20

*Business Option

Approved Electives: Any college course related to the student's specific vocational interest, i.e. business, science.

(Associate of Applied Science Degree Program - continued)

Sophomore Year

Fall Quarter:

		Credits
ACCT 101	Principles of Accounting* or	
DPCS 242	Advanced FORTRAN Language**	5
DPCS 260	Microprocessor Architecture	4
DPCS 265	System Documentation & Design	5
GBUS 217	Business Statistics* or	
MATH 121	Intro to Probability & Statistics**	5
		--
Total		19

Winter Quarter:

ACCT 102	Principles of Accounting* or	
ENGR 101	Engineering Drawing**	3-5
DPCS 261	Microsystems Development & Testing	5
DPCS 266	Supervised Cooperative Work Exp. Seminar	2
DPCS 267	Supervised Cooperative Work Experience	3
	Approved Elective	5

Total		18-20

Spring Quarter:

		Credits
ACCT 105	Managerial Accounting*	5
DPCS 232	Advanced COBOL Language*	5
DPCS 266	Supervised Cooperative Work Exp. Seminar	2
DPCS 267	Supervised Cooperative Work Exp.	3
Approved Electives**		5-10

Total		15-20

*Business Option
**Science Option

Approved Elective: Any college course related to the student's specific vocational interest, i.e. business, science.

Certificate Option
(For those with a previous degree)

Freshman Year

Fall Quarter:	Credits
DPCS 101 Technical Introduction to Data Processing	5
DPCS 160 Intro to Microprocessors	3
	--
Total	8

Winter Quarter:	Credits
DPCS 161 Electronics Survey & Lab	5
DPCS 171 Microprocessor Assembly Language Programming	5
DPCS 251 BASIC Language	2
DPCS 252 Advanced BASIC Language Programming	3
	--
Total	15

Spring Quarter:	Credits
DPCS 232 Advanced COBOL Language or	
DPCS 242 Advanced FORTRAN Language	5
DPCS 265 System Documentation & Design	5
	--
Total	10

(Certificate Option - continued)

Sophomore Year

Fall Quarter:	Credits
DPCS 232 Advanced COBOL Language or DPCS 242 Advanced FORTRAN Language	5
DPCS 265 System Documentation and Design	5
	--
Total	10

Winter Quarter:	Credits
DPCS 261 Microsystems Development & Testing	5
	--
Total	5

Spring Quarter:	Credits
DPCS 269 Microprocessor Thesis Project	5
	--
Total	5

Courses are taken in other departments such as computer science, business, technical writing, and math. At least one course per quarter is taken in the software engineering technology sequence.

Courses are taught through lectures and labs. Electronics is taught in the already existing electronics laboratory. The focus is on projects. Much time is spent "on the computers". According to Lecoq, it does not matter whether that computer is an Apple, TRS-80, IBM-PC or mainframe. Students must complete one project. They also have the opportunity to use the Washington State University computer -- AMDAHL.

The courses focus on learning how to "design", rather than how to code with a programming language. Designs of projects are first completed before the student is even allowed to get near a computer. The focus at that time is not on learning a language but instead using the language as a tool to enter the design effectively into the computer. Students must learn one or more high level language such as PASCAL, FORTRAN, or COBOL and one assembly language. The important factor is to understand a design process that could be implemented in any language.

Part of the curriculum includes the Microprocessor Thesis Project which is a design project , either a combined software/hardware application or just software. Students have completed significant works which have since been successfully marketed. Examples are:

1. a software driven light pen (to date, 500 orders have been received by the student for this product)
2. computer terminal for the blind (Radio Shack gave it an award),
3. wind survey device for windmill installations,
4. combination nutrition development and advertising scheme for supermarkets (software),
5. pre-flight planner for pilots which keeps pilots up-to-date during a flight,
6. simulation of a drug infusion pump (designed the hardware and the software),
7. voice synthesizer for larengectomy patients, and an
8. automated reagent dispense and bottling system.

The students who attend this program breakdown as follows.

60% career change full-time students
40% post-high school

Most of the courses are offered in the day program although some courses are offered at night.

Equipment

Equipment was chosen with a limited budget. It is the belief of the instructor that complex test equipment is not needed to understand practical fundamentals. Bread board boxes, signal generator boxes, integrated circuits, and oscilloscopes are all included. The fancy test equipment would be nice to have in a lab but not necessary. It is important that students understand what goes on inside a computer and what it takes to interface something with the computer, but it does not matter what microprocessor is used. If a student learns one, the knowledge can be easily transferred to another machine.

A lab could also use a logic analyzer and an incircuit emulator.

Again, students need access to equipment in a project-oriented program such as this. This means time on microcomputers and access to a larger mainframe computer.

Faculty

There is one faculty member who teaches the courses specific to the software engineering technician program. Other faculty members are staff of other departments such as computer science, business, math, etc. It is expected that the faculty will be expanded in the near future.

Placement

Most placements are as Programmers in engineering applications or Sales Personnel in a computer-related company. Opportunities exist in data processing, accounting, manufacturing, aerospace, engineering and a variety of other fields.

Future Trends

Aside from the expected growth in the program, one factor which needs to be resolved is the electronics training that the students receive. The basic electronics course is often too difficult for some students. In addition, that course does not currently transfer to a four-year program. It is expected that the electronics course will be upgraded so that it can be transferred to an engineering or computer-science program. That means it will be a more difficult sequence. It will be made possible however for some students to take the business degree option and substitute business courses for the electronics course.

PROGRAM: Electromechanical Technology
INSTITUTION: Central Maine Vocational Technical
Institute
1250 Turner Street
Auburn, Maine 04210
(207) 784-2385
CONTACT PERSON: Roger Bertrand
DEGREE(S): Four semester diploma in Applied Science or Associate Degree in Applied Science (Diploma completed plus 12 credit hours of asssociate degree level courses in communications, business studies and social science)
DATE PROGRAM BEGAN: September 1964

History

Central Maine Vocational Technical Institute traces its origin to 1963 when the Maine Legislature submitted to public referendum the question of whether or not a post- secondary vocational training program should be established in Adroscoggin County. The voters of Maine gave their consent for such an institution in November, 1963. In September, 1964, Androscoggin State Vocational Institute opened its facilities in Lewiston. During its first year, the institution enrolled 48 students in four programs (Auto Mechanics, Building Construction, Industrial Electricity, and Architectural Drafting). Seven instructors and six staff persons worked at the facility.

The first graduating class received their diplomas in June, 1965. Later in the year, the State Board of Education renamed the institution Central Maine Vocational Technical Institute. In January, 1966 the school was moved to Auburn, Maine.

In 1964, the Electromechanical Technology program began under the program title, Industrial Electricity. The objectives were to teach the electrical skills necessary for students to enter the industrial electrician field. During 1972 to 1974, several changes took place. Process Control Instrumentation was merged with the Industrial Electricity program and also Electronics and was expanded within the program. With the combined efforts of the faculty and Advisory Committee, these areas were integrated together to formulate a unified concept with a new name, Electromechanical Technology.

Several computer programming courses have recently been added to the curriculum.

The Program

The Electromechanical Technology program prepares students for careers in an expanding field that requires technicians capable of dealing with the challenge of rapid changes in technology. Stress is placed on the development of a thorough background in the fundamentals of electricity and electronics. Classroom study, which provides a solid theoretical foundation, is balanced by assigned laboratory activities, where students become skilled in the use of electronic test instruments associated with digital ciruitry, semiconductor and microprocessor circuit analysis, and circuit fabrication. Computer and programmable controller technology is also taught. Throughout the program emphasis is placed on the application of skills to industrial situations that utilize electronics and computer controlled instrumentation.

In the program, every attempt is made for the student to develop the knowledge and skills necessary to analyze and troubleshoot the automated systems that are found in high technology industries. By combining lab activities and related information in digital electronics, basic electrical/electronic concepts, solid state devices and switching circuits students recveive a solid background. In the second year the student further develops technical skills by working with microprocessors, computer principles, programming, instrumentation, and industrial programmable controllers.

The program is structured as a full-time day program but a night program is currently being established.

The courses are offered in a two-year program which offers the option of earning either a Diploma or an Associate Degree in Applied Science. Students pursuing the Associate Degree option must complete the diploma requirements and an additional 12 credit hours of associate degree level courses in the following subject areas:

Communications	3
Business Studies	6
Social Science	4

Prerequisites

Those seeking admission to the Electromechanical Technology Program must 1) submit an application form and related materials, 2) take the CMVTI diagnostic test, and 3) meet with the program chairperson for an interview.

Requirements for admission include:

-Graduation from an approved high school or an acceptable equivalent such as the State High School Equivalency Diploma

-Successful completion of one unit each in Algebra I, Algebra II, and General Physics,

-Good reading skills.

In addition, the successful completion of courses in Trigonometry, General Chemistry and Mechanical Drawing is desirable, but not required.

Course Descriptions

The curriculum for the Electromechanical Technology Program follows.

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Basic Electricity I

SEMESTER SCHEDULED: X 1st ___ 2nd ___ 3rd ___ 4th

COURSE NO. EM-051

CREDIT HRS. 4

CONTACT HRS. ______

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units ______

COURSE CATALOG DESCRIPTION: This course is the student's first course in electricity and covers the basic concepts of mass, force, work, and energy. Atomic structure and units of electrical charge are covered as they apply to DC circuits. Necessary test equipment will also be covered in this unit.

Particular emphasis is placed on: Ohm's Law, series, parallel, and series-parallel circuits. Power in resistive circuits, Kirchoff's voltage, and current laws, as well as advanced techniques such as Thevenin's theorem, Norton's theorem, and deltawye transformations.

Applications include: the solutions of complex electrical problems, and troubleshooting electrical circuits. This course is a firm foundation for future studies of more advanced courses in the electrical and electronics area.

TESTS AND EVALUATION:

Complete the following items:

1.0 Homework assignments
2.0 Lab assignments
3.0 Assigned examinations
4.0 Outside research projects

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology	COURSE NO. EM-714
COURSE: Digital Logic	CREDIT HRS. 4
SEMESTER SCHEDULED: X 1st ___ 2nd ___ 3rd ___ 4th	CONTACT HRS.
	Lecture and/or Recitation 60 Hours
	Shop/Lab 60 Hours
	Student Outside Assignments 60 Hours
	No. of Units

COURSE CATALOG DESCRIPTION: This course is a study of basic principles and techniques used in modern digital systems. Digital circuits utilizing all common logic functions are developed by the student and tested in the lab.

Particular emphasis is placed on: binary arithmetic, logic gate circuits, flip-flops, counter circuits, shift registers, frequency dividers and troubleshooting techniques using oscilloscope with various pulse generators and logic analyzer.

Applications include: Breadboard and analyze experiments that demonstrate principles, concepts and applications of integrated circuit chips using TTL 7400 and CMOS integrated circuit families.

COURSE OBJECTIVE OR CENTRAL CONCEPT: The content of Digital Logic is designed to introduce the student in the fundamentals of digital circuitry and digital logic, by presenting how gates can be combined to provide complex logic functions used in modern digital technology.

TESTS AND EVALUATION:

Lab experiments
Assigned problems
Assigned examinations
Classroom participation
Assigned reading

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Switching Circuits

SEMESTER SCHEDULED: X 1st ___ 2nd ___ 3rd ___ 4th

COURSE NO. EM-058

CREDIT HRS. 4

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course is a study of: functioning of divices that are primarily used for manual switching of circuits such as a single pole, three way and four way switches, fuses, circuit breakers, thermostats and contactors.

Particular emphasis is placed on: methods of wiring these devices into a system, following National Electric Code procedures, also layout and interpreting electrical diagrams used in electrical blueprints and schematics.

Applications include: wiring of single pole, three way, four way switches to control lights and receptacles, low voltage remote control systems, time clocks and photo cell along with heating and oil burner relays, thermostats, and contactors wired together into switching systems.

COURSE OBJECTIVE: Switching Circuits is designed to bridge together a combination of sources, Lab projects, text, word problems and the N.E.C. to produce a student with a sound fundamental backgound in wiring practices, wiring and schematic diagram interpretation, selection-use of various electrical devices, and basic control theory and practical applications.

EVALUATION:

1.0 Assigned reading and problems
2.0 Lab projects
3.0 Quizzes and examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-706

COURSE: Computer Literacy

CREDIT HRS. 3

SEMESTER SCHEDULED: X 1st ___ 2nd ___ 3rd ___ 4th

CONTACT HRS. ____

Lecture and/or Recitation 45 Hours

Shop/Lab ____

Student Outside Assignments ____

No. of Units ____

COURSE CATALOG DESCRIPTION: Computer Literacy is intended not only to explore the tasks to which computers are assigned but to offer an introduction to using an Apple microcomputer to accomplish tasks such as word processing, spread sheet analysis and data base management. In addition to Apple BASIC programming a brief historical perspective will be covered.

COURSE OBJECTIVE: Topics covered in Computer Literacy will introduce those without previous experience to various applications of computers in our society and provide a basis upon which further study in specific areas can be supported.

EVALUATION:

Class participation
Assigned projects
Quizzes and examinations
Computer experiments

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Learning Resources

COURSE: Binary Arithmetic & Boolean Algebra

SEMESTER SCHEDULED: ___ 1st X 2nd ___ 3rd ___ 4th

COURSE NO. LRM 015

CREDIT HRS. 3

CONTACT HRS. 45

Lecture and/or Recitation 45 Hours

Shop/Lab 0 Hours

Student Outside Assignments 90 Hours

No. of Units 12

COURSE CATALOG DESCRIPTION: The student will be introduced to the binary system with its language and laws, truth tables, practical simplification techniques, positional number systems, translation between radices, logic gates, designing logic circuits, and application of Boolean algebra to computer circuits.

COURSE OBJECTIVE OR CENTRAL CONCEPT: To prepare the student with the necessary mathematical background for functioning effectively in logic circuits.

TEACHING PERSONNEL REQUIREMENT: One instructor

TESTS AND EVALUATION:

12 objective quizzes and 3 objective tests.

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Basic Electricity II

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
	X		

COURSE NO. EM-054

CREDIT HRS. 4

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 45 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course in Basic Electricity II is designed to prepare the student in the areas of logical analysis, testing, and trouble-shooting. A thorough coverage of fundamental alternating current concepts shall be presented. This unit is essential for the student's understanding of electricity and is a foundation for the study of more advanced topics.

Particular emphasis is placed on: AC voltage and current, capacitors, inductors, reactance, impedance, power factor, frequency, and resonance.

COURSE OBJECTIVE: This course is designed to bridge together a combination of sources. Lab experiments, text, word problems, and study guide form a functioning system to assist the student outside of class when the instructor is not available. This will result in more efficient use of study time. Upon successful completion of this course the student will have gained a sound fundamental background in AC circuits.

EVALUATION: (types to be used)

1.0 Assigned reading and problems
2.0 Lab experiments and reports
3.0 Quizzes and examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Basic Electronics

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
	X		

COURSE NO. EM-710

CREDIT HRS. 4

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course is a study of: basic atomic theory, semiconductor principles, the PN junction, zener diodes, tunnel diodes, and opteolectronic devices such as photo conductive cells, photovoltaic cells, photodiodes, and light-emitting diodes.

Particular emphasis is placed on: methods of biasing, I-V characteristics, diode ratings and parameters, the effects of temperature on diode characteristics, methods of circuit analysis, and the selection of replacement devices. The operation and use of test equipment will also be a major part of this unit.

Applications include: Power supply rectifiers, voltage doublers, voltage regulations, diodes clippers, clampers, and peak detectors. Applications for tunnel diodes and optoelectronic devices include high speed switching, flame detectors, lighting control, and photographic exposure meters.

COURSE OBJECTIVE: This is the first unit in the area of Active-Non-Linear circuit elements and their applications. The unit begins with an introduction to solid-state electronics theory, and the P-N junction diode. Analysis includes diode equivalent circuits, forward and reversed biased diode junctions, and solid-state diode approximations. Application topics include basic rectifier circuits, signal clippers and clampers and zener diode voltage regulators.

TESTS AND EVALUATION:

1. Homework assignments
2. Lab assignments
3. Assigned examinations
4. Outside research projects

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-715

COURSE: Digital Systems

CREDIT HRS. 4

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
	X		

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course is a study of: complex systems utilizing circuits developed in EM-714.

Particular emphasis is placed on: logic circuits, interfacing requirements, system specification, logic and wiring diagrams and troubleshooting.

Applications include: design, construction and checkout ot TTL memories, MODEMS, multiplexers, decoders, demultiplexers, sequencers, timers, UART's and computer interface. A basic computer will be designed and assembled in this course.

COURSE OBJECTIVE OR CENTRAL CONCEPT: The content of Digital Systems is designed as a continuation of the digital logic course and introduces the principles involved in the transfer and storage of data as used in computer systems.

TESTS AND EVALUATION:

Lab experiments
Assigned problems
Assigned examinations
Classroom participation
Assigned reading
One semester project
Written reports on each task

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Computer Programming I

SEMESTER SCHEDULED:

___	X	___	___
1st	2nd	3rd	4th

COURSE NO. EM-707

CREDIT HRS. 3

CONTACT HRS. ______

Lecture and/or Recitation 45 Hours

Shop/Lab ______

Student Outside Assignments ______

No. of Units ______

COURSE CATALOG DESCRIPTION: The computer is at the heart of the current revolution in technology. This course will prepare the student to use the power of the computer by covering its historical development, current and future applications and an introduction to the BASIC Programming Language. This foundation will allow the student to develop further computer interests from a firm base.

COURSE OBJECTIVES:

The student will:

1. Understand the historical development of the computer
2. Befamiliar with operating system and screen editing commands and procedures
3. Develop elementary BASIC programming skills

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-712

COURSE: Solid State Devices

CREDIT HRS. 4

SEMESTER SCHEDULED:	1st	2nd	3rd	4th
			X	

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course in solid state devices is a study of: bipolar junction transistors, field effect transistors, and MOSFETS. Necessary test equipment will also be covered in this unit.

Particular emphasis is placed on: analyzing common-base, common-emitter, and common-collector transistor amplifiers using the load-line, and approximate method. Characteristic curves are studied with the aid of curve tracers, and a comparison of voltage gain, current gain, and power gain is made. Field effect transistor amplifiers are studied with emphasis on drain curves, ratings, and parameters. Basic common-source amplifiers and bias stability are covered in detail. Applications include: about any type of electronic equipment a student will be required to troubleshoot.

COURSE OBJECTIVE OR CENTRAL CONCEPT: This course in solid state devices is a study of: bipolar junction transistors, field effect transistors and MOSFETS. Necessary test equipment will also be covered in this course. Particular emphasis is placed on: Analyzing common-base, common-emitter, and common-collector transistor amplifiers using the load-line and approximation methods. Characteristic curves are studied with the aid of curve tracers, and a comparison of voltage gain, current gain, and power gain is made between different classes of amplifiers. Field effect transistor amplifiers are studied with emphasis on drain curves, ratings and parameters. Basic common-source amplifiers and bias stability are covered in detail.

TESTS AND EVALUATION:

1. Outside research projects
2. Homework assignments
3. Lab assignments
4. Assigned examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Learning Resources

COURSE: Technical Trignometry

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
	X		

COURSE NO. LRM 013

CREDIT HRS. 3

CONTACT HRS. 45

Lecture and/or Recitation	45 Hours
Shop/Lab	0 Hours
Student Outside Assignments	90 Hours

No. of Units 6

COURSE CATALOG DESCRIPTION: This course will cover introduction to trigonometry, trigonometry of any angle, oblique triangles, radian measure, trigonometric identities, equations and graphs, and introduction to complex numbers.

COURSE OBJECTIVE OR CENTRAL CONCEPT: To prepare the student with the necessary mathematical background for functioning effectively in alternating current circuits.

TEACHING PERSONNEL REQUIREMENT: One instructor

TESTS AND EVALUATION:

6 objective quizzes and 3 objective tests

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-128

COURSE: Instumentation Control Systems 1

CREDIT HRS. 3

SEMESTER SCHEDULED: ___ 1st ___ 2nd X 3rd ___ 4th

CONTACT HRS. ______

Lecture and/or Recitation 60 Hours

Shop/Lab ______

Student Outside Assignments 45 Hours

No. of Units ______

COURSE CATALOG DESCRIPTION: The content of Instrumentation Control Systems 1 is designed to prepare the student in the areas of logical analysis, troubleshooting, maintenance and selection of primary devices used for measuring and control of a process stream.

Particular emphasis is placed on: the basic theory of pressure, temperature, conductivity, humidity, liquid level, and flow.

COURSE OBJECTIVE: The content of Instumentation Control Systems 1 is designed to prepare the student in the areas of logical analysis, troubleshooting, maintenance, and selection of primary devices used for measuring and control of a process stream.

EVALUATION:

Complete the following items:

1.0 Assigned reading and problems
2.0 Individual assignments
    (Term paper-assigned topic)
3.0 Lab projects
4.0 Quizzes and examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electromechanical Technology

COURSE: Industrial Controls

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
		X	

COURSE NO. EM-135

CREDIT HRS. 4

CONTACT HRS. 60 Hours

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course is a study of: electromagnetic controls for automated industrial systems that include the use of magnetic starters, relays, contactors, pushbuttons, roto pushbuttons, selector switches, pneumatic and solid state timers, photo cell controls, proximity switches, alternating current motors, and programmable controllers.

Particular emphasis is placed on: designing and interpreting diagrams such as schematics and wiring diagrams that describe the sequence of operation of an electrical system.

Applications include: wiring of stop-start circuits, inching circuits, forward reverse circuits, two speed controls, reduced voltage controls which include auto-transformer, wye-delta, part winding, solid state, the application of timers, photo-cell controls, and working with programmable controllers, devleoping programs using Texas Instrument's 510 and 550 programmable controllers.

COURSE OBJECTIVE: The content of Industrial Controls unit is designed to prepare the student in the areas of logical analysis, troubleshooting and wiring; by presenting a thorough coverage of the fundamental concepts in motor control circuitry. In addition, this unit will assist the student in understanding and developing electrical control diagrams, three phase and single phase motors and transformers and their applications in motor control industrial wiring.

TESTS AND EVALUATION:

Complete the following items:

1.0 Projects and research & development
2.0 Assignment book
3.0 Assigned chapters in Delmar Control book
4.0 Industrial research project
5.0 Written technical report on industrial control system
6.0 Assigned examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-708

COURSE: Computer Programming II

CREDIT HRS. 3

SEMESTER SCHEDULED: __ 1st __ 2nd X 3rd __ 4th

CONTACT HRS. ______

Lecture and/or Recitation 45 Hours

Shop/Lab ______

Student Outside Assignments ______

No. of Units ______

COURSE CATALOG DESCRIPTION: this course is the follow-up to EM-707 Computer Programming I, once a solid background in BASIC language command and program structure has been established. Along with some experience in problem solving with the Apple Computer, students are ready to begin studying how to effectively utilize their skills and expand upon them to create, store, manipulate and generate reports from data files. Focus will be on file structure for APPLESOFT BASIC but skills will be easily transferred to other BASIC dialects.

COURSE OBJECTIVES:

The student will:

1. Be able to explain the steps involved in developing clear, concise BASIC program structure.
2. Become familiar with sequential data files.
3. Become familiar with random access data files.
4. Develop skills in employing data files in solving programming assignments.

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Computer Principles

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
			X

COURSE NO. EM-717

CREDIT HRS. 4

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: The Computer Principles course is a study of the computer structure and its use in practical applications, which include, the use of the Minc-11 computer for programming and interfacing through A/D and D/A converter modules.

The ZX81, VIC-20, and TI-99 Microcomputers are used for R&D projects involving both BASIC and machine languages to manipulate various electronic and electromechanical devices and systems such as Home Security, Traffic Control, Home Heating Control, Automobile Instrumentation, and Robotics.

COURSE OBJECTIVE: The content of the Computer Principles course is designed to give the student practical experience in constructing and troubleshooting various computer interfacing projects.

Instrumentation and robotics are joined together with computer technology to demonstrate the various applications.

EVALUATION: (types to be used)

- Lab experiments
- Assigned problems
- Assigned examinations
- Classroom participation
- Application projects

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Linear Intergrated Circuits

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
			X

COURSE NO. EM-713

CREDIT HRS. 4

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course is a study of: the theory and application of operational amplifiers and linear intergrated circuits, including instrumentation, signal generation and control. Necessary test equipment will also be covered in this unit.

Particular emphasis is placed on: inverting and noninverting amplifiers, comparators, power supply regulators, differential amplifiers, active filters, and intergrated circuit timers. Emphasis is also placed on the limitations of operational amplifiers such as bandwidth, slew rate, noise and frequency response.

Applications include: the design and troubleshooting of complex electronic circuits, sued to provide inexpensive solutions to practical problems.

COURSE OBJECTIVE OR CENTRAL CONCEPT: This course is a study of: the theory and application of operational amplifiers and linear intergrated circuits, including instrumentation, signal generation, and control. Necessary test equipment will also be covered in this unit.

Particular emphasis is placed on: inverting and noninverting amplifiers, comparators, power supply regulators, differential amplifiers, active filters, and intergrated circuit bandwidth, slew rate, noise, and frequency response.

TESTS AND EVALUATION:

Complete the following items:

1.0 Outside research projects
2.0 Homework assignments
3.0 Lab assignments
4.0 Assigned examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-129

COURSE: Instrumentation Control Systems II

CREDIT HRS. 4

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
			X

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 30 Hours

Student Outside Assignments 45 Hours

No. of Units

COURSE CATALOG DESCRIPTION: A continuation of EM-128, the student is introduced to the elements which make up a feedback control loop.

The operation and open loop response of a 3 mode controller will be discussed starting with a basic proportional controller, proportional and reset, and finally proportional and reset derivative.

Valves, valve characteristics, and the selection and sizing of the valve for various process conditions will be discussed along with controller adjustment and analysis.

COURSE OBJECTIVE: The content of Instrumentation Control Systems is designed to prepare the student in the areas of logical analysis, troubleshooting, and maintenance of instrumentation currently in use by industry to monitor and control process variables. In addition, this unit will enable the student to identify functional sub systems normally encountered in process control.

EVALUATION:

1.0 Assigned reading and problems
2.0 Individual assignments
    (Term paper-assigned topic)
3.0 Lab projects
4.0 Quizzes and examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-709

COURSE: Computer Programming III

CREDIT HRS. 3

SEMESTER SCHEDULED: ___ 1st ___ 2nd ___ 3rd X 4th

CONTACT HRS.

Lecture and/or Recitation 45 Hours

Shop/Lab

Student Outside Assignments

No. of Units

COURSE CATALOG DESCRIPTION: PASCAL has been acknowledged as the most significant advancement in microcomputer software since BASIC. It will be one of the premier-programming languages of the 80's. While offering powerful control and data structures, PASCAL does not require extensive machine support to provide these features and will be taught on Apple II and micros in a "hands-on" environment.

COURSE OBJECTIVE: The content of Computer Programming III is designed to introduce the experienced BASIC programmer to PASCAL and provide elementary competence in the use of program elements, data types, variable types, records and arrays, control and data file structures.

EVALUATION:

Computer experiments in PASCAL
Class participation
Reading assignments
Problem solving exercises
Project assignments
Examinations

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE NO. EM-501

COURSE: National Electric Code

CREDIT HRS. 3

	1st	2nd	3rd	4th
SEMESTER SCHEDULED:				X

CONTACT HRS.

Lecture and/or Recitation 45 Hours

Shop/Lab

Student Outside Assignments 45 Hours

No. of Units

COURSE CATALOG DESCRIPTION: This course is a comprehensive study of the National Electrical Code. The NEC is adopted by the State of Maine as a guide for safe electrical installations.

Particular emphasis is placed on: the interpretation of the intent of the code rules as they apply to everyday electrical installations.

Application includes the calculation of loads to determine branch circuit, overcurrent, feeder, and services sizes. Grounding methods. Proper selection and installation of conductors and equipment.

COURSE OBJECTIVE OR CENTRAL CONCEPT: The content of the National Electrical Code unit is to prepare the student in the areas of interpreting and calculating the articles within the National Electrical Code, by presenting a thorough coverage of the fundamentals in the code book. In addition, this unit applies to all units within the Electro-Mechanical Technology program.

TESTS AND EVALUATION:

Completion of quizzes and exams
Completion of workbook

CENTRAL MAINE VOCATIONAL TECHNICAL INSTITUTE

COURSE PLAN

PROGRAM: Electro-Mechanical Technology

COURSE: Microprocessors

SEMESTER SCHEDULED:

1st	2nd	3rd	4th
		x	

COURSE NO. EM-716

CREDIT HRS. 4

CONTACT HRS.

Lecture and/or Recitation 60 Hours

Shop/Lab 60 Hours

Student Outside Assignments 60 Hours

No. of Units

COURSE CATALOG DESCRIPTION: the Microprocessor course is a study of the architectural composition of some of the most widely used microprocessors, namely, 6800, 8080, 8085, and Z80, by a study of programming in machine and assembly language.

Applications include programming in machine language, interfacing to A/D and D/A converters, keyboards, and displays through a peripheral interface device and to external extended RAM memory, debugging and troubleshooting applications using the Intel SDK-85, Elf 1802, and Heath E T 3400 microprocessors trainers.

COURSE OBJECTIVE: The content of the Microprocessor course is designed to give the student a basic understanding of the microprocessor and its applications by studying the structure and functions of several of the most popular devices.

EVALUATION: (types to be used)

- Lab experiments
- Assigned problems
- Assigned examinations
- Classroom participation
- Application projects

Equipment

To facilitate the learning environment, the Electromechanical Technology has five different lab areas. This is where major projects are completed. The equipment in each lab is listed below.

Digital Lab	E&L Digi-Designers for bread boarding all the integrated digital families Tetronix oscilloscope
Microprocessor Lab	6800 Heathkit trainers, Commodore 64 computers, Pascal-Dana logic analyzer
Computer Lab	18 Apple Computers with dual disk drives 3 Columbia computers with CAD equipment
Instrumentation Lab	5 TI programmable controllers Allen Bradley programmable controller Digital Minc computer
Electronics Lab	Hickot System B&K oscilloscopies Various test equipment

Faculty

The following faculty are in the EMT department

Roger Bertrand	27 years in Electronics	MS Degree
Clayton Peary	35 years in Electronics	Technician
Dave Stone	14 years in Electronics	BS Degree
Jerry Grant	37 years in Electronics	Technician
Vaikko Allen	5 years Computer Program	Assoc Degree

Placement

Upon graduation, students accept positions as electrical/electronics technicians, instrumentation technicians, and computer technicians, working at tasks as widely diverse as product development, quality control testing, fabrication, systems installation, and maintenance of equipment and systems. To illustrate the jobs graduates move into, refer to the following Class of 1983 Placment Profile.

Employer	Position
Fairchild	Electronics Technician
Fairchild	Electronics Technician
James R.Otis	Instrumentation Technician
Computer Ctr.	Computer Techncian
Computer Sales	Computer Technician
Fairchild	Computer Technician
Electrician	Electricians Assistant
Shape	Electrical Mechanical Technician
Digital	Electrical Techncian
Boise	Instrument Technicial
Digital	Electronics Technician
Fairchild	Electronics Technician
Digital	Electronics Techncian
Shape	Electrical Techncial
GCA	Field Service Technician
GCA	Field Service Technician

PROGRAM: Electronics: Computer Maintenance Technician
INSTITUTION: Alliance City School District
Adult Continuing Education
200 Glamorgan Street
Alliance, Ohio 44601
(216) 821-2100
CONTACT PERSON: Joseph C. Smith
DEGREE: Certificate of Completion after 34 weeks
PROGRAM BEGAN: November 1983

History

This program was orignially offered as a two-year program in electronics and repair. It has now been condensed to a one-year program. JTPA (The Job Training Partnership Act) is interested in enrolling 20 participants in the program. After that time, the program will become a permanent part of the curriculum.

The Program

The program is offered as a full-time day program from 3:00-10:00 p.m., 5.5 days per week (includes Saturday morning). At present, 19 of the enrollees are supported by JPTA funds, and 5 are buy-ins from industry. The program is also linked to the Workmen's Compensation Program at the Divison of Vocational Rehabilitation, the Work Incentive Program (WIN) and programs for the vision impaired.

The program is designed to provide clients with the necessary skills to enable them to assume entry level positions as Electronics/Computer Maintenance Technicians. A technician is required to perform the following tasks:

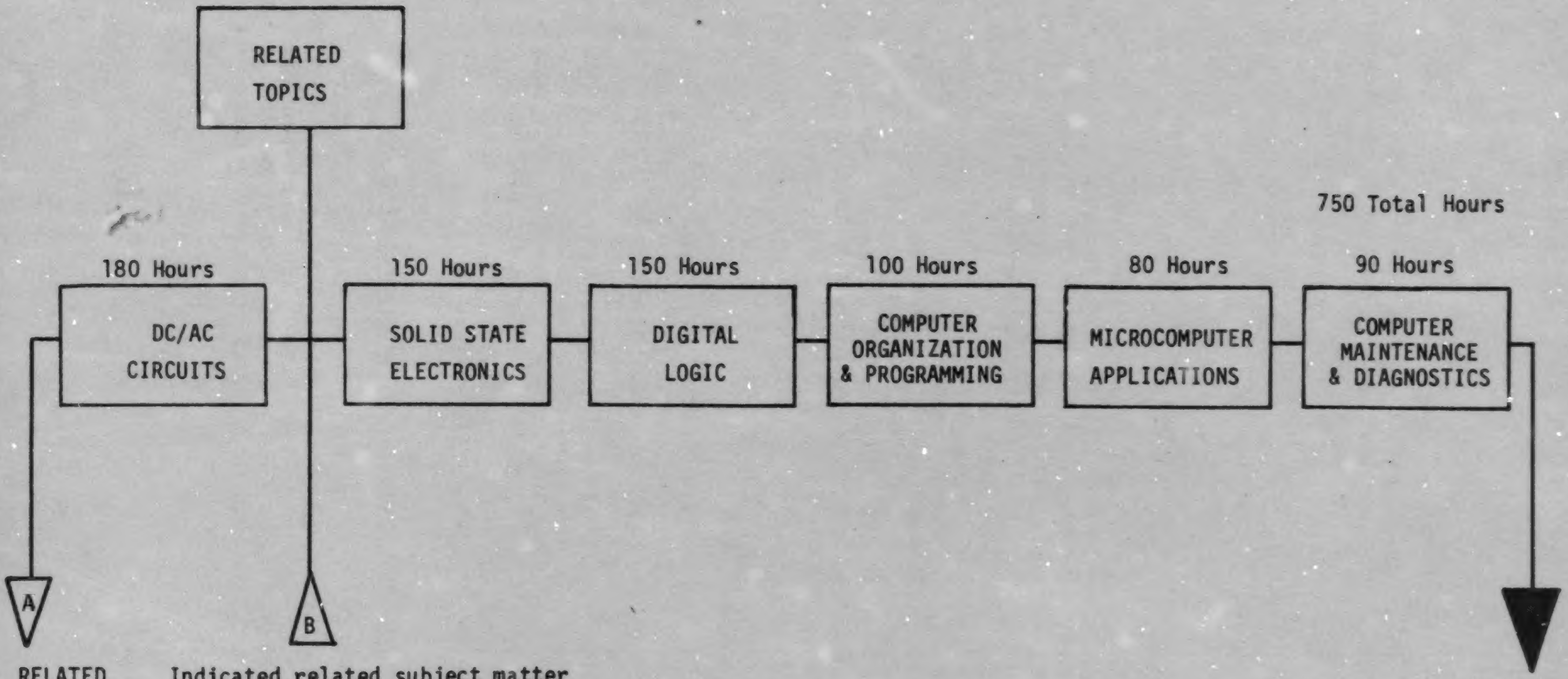
-repair electronic equipment such as computers, industrial controls, transmitters and servomechanisms
-follow blueprints and manufacturers' specifications
-test electronic components and circuits to identify defects, using oscilloscopes, signal generators, ammeters, and voltmeters
-replace defective components and wiring and adjust mechanical parts using handtools and soldering iron
-calibrate equipment according to specifications and calibrating testing instruments.

The program lasts for thirty-four weeks, with thirty-five hours of instruction per week (approximately 1200 hours, 750 Lab hours, 450 related). The program's curriculum is comprised of six sub-units. The hours per sub-unit can vary depending on the capability of the students. Students will proceed from one sub-unit to another on the basis of their attainment of specified minimum competencies. The sub-units and description of each follows.

FLOW DIAGRAM LEGEND

The curriculum flow diagram provides course titles and a flow sequence for the program. The hours can vary depending on the capability of your students and the depth and amount of emphasis you wish to give each topic. Detailed course outlines for each block on the diagram completely define the course content involved.

COMPUTER MAINTENANCE TECHNICIAN


RELATED TOPICS
750 Total Hours
180 Hours
DC/AC CIRCUITS
150 Hours
SOLID STATE ELECTRONICS
150 Hours
DIGITAL LOGIC
100 Hours
COMPUTER ORGANIZATION & PROGRAMMING
80 Hours
MICROCOMPUTER APPLICATIONS
90 Hours
COMPUTER MAINTENANCE & DIAGNOSTICS
A
B
COMPUTER MAINTENANCE TECHNICIAN

RELATED TOPICS	Indicated related subject matter applicable to Curriculum such as Mathematics and Physics.
A	Entry Level - No prerequisites
B	Entry Level - Previous training or exposure

DC/AC Circuits

This course provides an excellent core curriculum. Circuit theory, and maximum use of circuit applications provide a step-by step circuit analysis covering: Laboratory Safety I, Power Sources, Series and Parallel Circuits, Electrical Measurements, Resistive Circuits, Thevenin's and Norton's Theorems, Magnetism, Alternating Current, Inductance, Capacitance, Transformers.

Solid State Electronics

This course investigates the basic concepts and devices associated with Digital Electronics. The student learns circuit configurations of solid state components and applies them toward the development of circuits including: Laboratory Safety Procedures, Symbols, Instruments I, Instruments II, Diodes, Rectifiers, Voltage Regulators, Clampers and Limiters, Transistors I, Transistors II, Amplification, Push-Pull Amplifiers, Field Effect Transistors, Mosfets, Photoelectric Effect, Thyristors, Unijunction Transistors, IC Operational Amplifiers, Series Resonance, Digital Gates, Timing Circuits. Experiments include the breadboarding of transistor and IC equivalents of the various circuits.

Digital Logic

This course introduces the student to digital logic concepts and techniques. Using a building-block approach, gates are combined with other digital devices to form functional circuits and more advanced devices. The student becomes familiar with number systems and the use of Boolean Algebra. With the interconnection of gates and flip flops, the following devices and concepts are studied: counters; decoders; shift registers; code systems; binary arithmetic decoder/drivers. Typical applications such as digital clocks are demonstrated.

Computer Organization & Programming

Utilizing a typical, stored-program digital computer with special displays, the student will study the instruction repertoire and how these are implemented within the machine. Basic flow charting and programming techniques will be utilized to write and operate programs with the machine.

Microcomputer Applications

This course includes study of the microprocessor, its language and applications. It also includes how to write and de-bug machine language programs, control data arrays, input/output devices, and interrupts. The study will use binary and hexadecimal numbers extensively.

Computer Maintenance and Diagnostics

Using typical logic and timing diagrams, the student will learn to trace logic timing in a typical machine. Through actual malfunction analysis of faults simulated in the machine, he will develop methodology for trouble-shooting digital systems.

A more detailed description of the curriculum components per each sub-unit follows.

DC/AC CIRCUITS

I. Safety in the Laboratory

1. Safety procedures
2. Shock Hazards
3. Short Circuits
4. Protection Devices

II. Parts and Symbols

1. Inventory of the Electricity Concepts Trainer
2. Symbols and Parts Identification
3. Wiring Procedures

III. Basic Electricity

1. Structure of Matter
2. Conductors & Insulators
3. Electrical Quantities

IV. Power Sources

1. Batteries
2. Solar Cells
3. Thermocouples

V. Electrical Circuits

1. Complete Circuits
2. Ohm's Law

VI. Series & Parallel Circuits

1. Series Circuits
2. Parallel & Compound Circuits
3. Meter Circuits

VII. Electrical Measurements

1. Voltage & Current Measurement
2. Reading Meter Scales

VIII. Resistance and Resistors

1. Measuring Resistance
2. Resistor
3. Color Code
4. Variable Resistors

IX. Resistive Circuits

1. Series Resistive Circuits
2. Parallel Resistive Circuits
3. Equal Resistance in Parallel
4. Compound Resistive Circuits

X. Thevenin's and Norton's Theorems

1. Thevenin's Theorem
2. Norton's Theorem

XI. Electrical Power and Energy

1. Power and Ohm's Law
2. Power Dissipation
3. Kilowatts

XII. Magnetism

1. Magnetic Poles and Fields
2. Temporary and Permanent Magnets
3. Magnetic Permeability

XIII. Electromagnetism

1. Magnetic Fields and Current
2. The Solenoid
3. Electromagnetic Induction
4. Electromagnetic Induction with Current

XIV. Applications of Electromagnetism

1. Electric Bell and Buzzer
2. Relay

XV. Alternating Current

1. Sine Wave Characteristics
2. Peak and Peak-to-Peak Voltages
3. Effective and Average Voltages

XVI. Inductance

1. Self-Induction in a Coil
2. Inductance and AC
3. Inductive Circuits
4. Circuit Applications of Inductance

XVII. Capacitance

1. Capacitor Charge and Discharge
2. Factors that Affect Capacitance
3. Parallel and Series Capacitors
4. Capacitor Charge

XVIII. Capacitive Circuits

1. Capacitance and Frequency
2. Series Capacitive Circuits
3. Parallel Capacitive Circuits
4. Circuit Applications of Capacitors

XIX. RLC Circuits

1. Series RLC Circuits
2. Parallel RLC Circuits
3. Resonance
4. Source Impedance

XX. AC Power

1. Resistive Circuits
2. Series Reactive Circuits
3. Parallel Reactive Circuits

XXI. Transformers

1. Induced Voltage and Current
2. Voltage and Current Ratios
3. Transformer Losses
4. Transformer Applications

XXII. Motors
1. DC Motors
2. Effects of Magnetic Fields
3. AC Motors

XXIII. Generators

1. AC Generators
2. DC Generators
3. Generator Construction

XIV. Semiconductors

1. N-Type and P-Type Materials
2. The PN Junction Diode
3. The Junction Diode as a Rectifier
4. NPN Junction Transistor
5. PNP/NPN Junction Transistors

SOLID-STATE FUNDAMENTALS

I. Laboratory Safety Procedures

   1. Short Circuits
   2. Laboratory Safety

II. Symbols

   1. Symbol Review
   2. New Symbols

III. Instruments I

   1. Low Voltage Power Supply Review
   2. Multimeter Review
   3. Oscilloscope Review

IV. Instruments II

   1. Signal Generator Review
   2. Signal Tracing

V. Diodes

   1. Semiconductor Diodes
   2. Zener Diodes

VI. Rectifiers

   1. Half-Wave Rectifier
   2. Full-Wave Rectifier
   3. Full-Wave Bridge Rectifier
   4. Filtering

VII. Voltage Regulators

   1. Shunt Voltage Regulators
   2. Series Voltage Regulators

VIII. Clampers and Limiters

   1. Clamping Circuits
   2. Clippers
   3. Limiters

IX. Transistors I

   1. Identifying Transistor Leads
   2. Testing Transistors for "Opens" and "Shorts"
   3. Testing Transistors for NPN or PNP

X. Transistors II

1. Transistor Current Control
2. Biasing Transistors
3. Power Dissipation in a Transistor

XI. Amplification

1. Amplifier Gain
2. Cascaded Amplifiers

XII. Push-Pull Amplifiers

1. Introduction to Push-Pull Amplifiers
2. Class B Push-Pull Amplifiers

XIII. Field Effect Transistors

1. FET Characteristics
2. Common-Source Amplifiers
3. Source-Follower Amplifiers

XIV. MOSFETS

1. MOSFET Characteristics
2. MOSFET Amplifiers
3. Manual Gain Control

XV. Photoelectric Effect

1. Photocell-Transistor Controlled Relay
2. Photoelectric Isolator

XVI. Thyristors

1. Characteristics of Thyristors
2. Trigger Circuits for Thyristors
3. Applications of Thyristors

XVII. Unijunction Transistors

1. UJT Characteristics
2. UJT Relaxation Oscillator
3. UJT Trigger Circuit

XVIII. IC Operational Amplifiers

1. IC Operational Amplifier Characteristics
2. Op-Amp Applications

XIX. Resonance

1. Series Resonance
2. Parallel Resonance

XX. Oscillators

1. Characteristics of Oscillators
2. Armstrong and Hartley Oscillators
3. Colpitts Oscillator

XXI. Digital Gates

1. Basic Logic Circuits
2. NOR/NAND Gates

XXII. Timing Circuits

1. Astable Operation
2. Monostable Operation
3. Applications of the 555

DIGITAL LOGIC

I. Logic Trainer Familiarization

1. Trainer Introduction
2. Circuit Modules
3. Special Assemblies

II. Safety

1. Laboratory and Work Safety
2. Environmental Hazards
3. Preventive Maintenance

III. Introduction to Digital Logic

1. Digital Systems
2. Digital Logic

IV. Binary Numbers and Codes

1. Binary Numbers
2. Binary Arithmetic and Codes

V. Logic Families and Basic Gates

1. AND Gates
2. OR Gates
3. Inverters

VI. Combinational Gates

1. NAND Gates
2. NOR Gates
3. Exclusive-OR Gates
4. Exclusive-NOR Gates

VII. Circuit Minimization Techniques

1. Boolean Algebra
2. Logic Simplification
3. Veitch Diagrams
4. Data Select Logic

VIII. Buffers, Inverters and Tri-State Logic

1. Non-Inverting Buffers
2. Inverting Buffers
3. Tri-State Logic

IX. Latches and Flip-Flops

1. Latches
2. RS Flip-Flops
3. D-Type and T-Type Flip-Flops
4. J-K and Master/Slave Flip-Flops

X. Encoders and Decoders

1. Encoders
2. Decoders

XI. Clocks and Signal Conditioners

1. Clocks and Signal Conditioners
2. Multivibrators
3. Schmitt Trigger Circuits

XII. Counters

1. Ripple Counters
2. Decade Counters
3. Synchronous and Asynchronous Counters
4. Up-Down Counters
5. Programmable Counters

XIII. Shift Registers

1. Serial In, Serial Out
2. Serial In, Parallel Out
3. Parallel In, Serial Out
4. Parallel In, Parallel Out
5. Ring Counters
6. Johnson Counters

MICROCOMPUTER APPLICATIONS

I. Introduction to Microprocessor

1. Organization
2. Machine Language
3. RAM (Random Access Memory)
4. ROM (Read Only Memory)

II. Binary and Hexadecimal Numbers

1. Requirement in the Microcomputer

III. Introduction to the Microprocessor System

1. Location of Components
2. Power Supply
3. Bus Structure
4. Input/Output

IV. Introduction to the Microprocessor Language

1. Writing a Machine Language Program
2. Entering the Program
3. De-bugging the Program

V. Input/Output of the Microprocessor

1. Serial Input
2. Serial Output
3. Parallel Input
   a. Hex Pad Keyboard
4. Parallel Output
   a. 7-Segment Display
5. Data Arrays

VI. Advanced Input/Output Formatting

1. Programming Techniques
2. Monitor Programs
3. Counters and Pointers

VII. Input/Out Devices

1. UART - Universal Asynchronous Receiver/Transmitter
2. PIA - Peripheral Interface Adapter
3. ACIA - Asynchronous Communications Interface Adapter

VIII. Interrupts

1. Priority
2. Programmable

IX. Interfacing

1. Digital to Analog
2. Analog to Digital
3. Machine Control

COMPUTER PROGRAMMING

I. Comparison of Language Levels

1. Machine Language Programming
2. Machine Assembly and Assemblers Programs
3. Procedure - Oriented Languages

II. Features of Assemblers

1. Field Structure
2. Labels
3. Assembler Operation Codes
4. Pseudo-Operations
5. Symbol table
6. Addresses
7. Conditional Assembly
8. Macro
9. Sub-routines
10. Comments

III.
1. Assembler Input and Output
2. Errors
3. Cross-assembly

IV. Examples of Z-80 (8080A) Assemblers

1. Z-80 Field Structure
2. Z-80 Labels
3. Z-80 Address Field
4. Z-80 Conditional Assembly

V. Assembly Language Programming

1. Flow Charting
2. Loops and Arrays
3. Arithmetic
4. Character Manipulation
5. Sub-routines

VI. Software Development Using Assembler

1. Problem Definition
2. Program Design
3. Coding
4. De-bugging
5. Testing
6. Documentation
7. Maintenance
8. Extension and Redesign

COMPUTER PROGRAMMING

I. Introduction to BASIC

1. Features
2. Program Structure
    a. Statements
    b. Commands
    c. Intrinsic Functions
3. Data Formats
4. Program Modes
    a. Command Mode
    b. Execution Mode

II. Program Preparation

1. Loading a Source Program
2. Changing a Source Program

III. Statements

1. Input/Output Statement
2. Declaration Statements
3. Control Statements
4. Assignment Statements
5. Remarks Statements

IV. Commands

1. System Commands
2. Program Execution
3. Editing Commands
4. Sizing Commands

V. Intrinsic Functions

1. Control Functions
2. Data Functions
3. Mathematical Functions
4. User Defined Functions

VI. Disk Operating Basic

1. System Requirements
2. Loading the Basic
3. Command Description
4. Special Control Characters
5. Disk File Input/Output
6. Error Messages

COMPUTER MAINTENANCE AND DIAGNOSTICS

I. Address Bus Familiarization

1. Explanation of address bus structures
    a. Bus Groups
    b. Signal Groups
2. Binary Display of Address Bus
3. Hexadecimal Display of Address Bus
4. Address Test Points
5. Bus Hand Shaking
6. Mother Boards
7. Bus Drivers

II. Data Bus Familiarizations

1. Explanation of Data Bus Structures
    a. Data Bus Group
    b. Signal Group
2. Binary Display of Data
3. Hexadecimal Display of Data
4. Data Test Points
5. Refreshing Memory Data
6. Static and Dynamic Memories
7. Read Access Time
8. Write Access Time
9. Memory System Cycle Time

III. Computer Control

1. Control Output
2. Control Input
3. Interrupt Control
4. Temporary Master Access (TMA) Control
5. Program Counter

IV. Z-80 Control System

1. MPU Control Status
2. Interface Bus Control Status
3. Data Test Points With Waveforms

V. Resident Program Commands

1. CT-60/61 Monitor Commands
2. Command Set Usage with Examples
3. Z-80 Control Register
4. Monitor Program Exercise

VI. Microprocessor Introduction

1. Z-80 and 8080A MPU
2. Z-80 MPU Architecture
3. Central Processing Unit (CPU) Registers
4. Special Purpose Register
5. Accumulator and Flag Register
6. General Purpose Register
7. Address Bus Instructions
8. Central Processing Timing
9. Instruction Fetch Timing
10. Memory Read or Write Timing
11. Input or Output Cycle Timing

VII. Z-80 Instruction Set

1. Load and Exchange
2. Block, Transfer and Search
3. Arithmetic and Logical
4. Rotate and Shift
5. Bit Manipulation
6. Jump, Call and Return
7. Input/Output
8. Basic CPU Control
9. Addressing Modes

VIII. Fault Analyzing Using the CT-81

1. Using the CT-81 as a Digital Logic Source
2. Using the CT-81 as a Logic Analyzer

IX. Data Out Faults on S100 Data Bus

1. Data Bit Faults
2. Enable Out Faults (ENO)
3. Scoping the Data Out Bus

X. Data in Faults on S100 Data Bus

1. Data Bus Bits in Faults
2. Enable in Faults
3. Scoping the Data in Bus and Control

XI. Address Bus Faults on the S100 Bus

1. Address Bit Faults
2. Address Control Faults
3. Read/Write Faults
4. Diagnosing Address Faults Using the Oscilloscope

XII. Analyzing Control Faults on the S100 Bus

1. Memory Request Fault
2. Input/Output Request Fault
3. Memory Read Faults
4. Memory Write Faults
5. Halt and Wait Faults
6. Scoping Control Faults Using MI as Reference

XIII. Input/Output Fault Analyzing

1. System Faults on the Serial Ports
    a. CRT
    b. Printer
2. System Faults on the Parallel Ports
3. Input/Output Faults using the Digital Recorder
4. Input/Output Faults using the Floppy Disk and Disk Controller

XIV. Analyzing System Faults

1. Using the Oscilloscope to Locate
2. Using the CT-81 to locate System Faults
3. Comparing the CT-81 to a Logic Analyzer
4. Diagnostic Programming to Locate Faults

Equipment

The program will use the basic electronics laboratory for instruction in the following:

- DC/AC Circuits
- Solid State Electronics
- Digital Logic

The program will use the computer laboratory for computer programming instruction in the following:

- Computer Literacy
- Basic Programming Language
- Assembler Language

(Equipment -
Televideo-816 CPU
800 A-user stations)

The program will use Computer Training Simulators to:

- Teach Microprocessor Applications
- Operate Z-80 Processors

To do maintenance and repair the program will use the Diagnostic Trainer system by Energy Concepts (3254 Kilbourn Avenue, P. O. Box 41908, Chicago, Illinois 60641). With this system, the instructor can modify the terminal so that it will malfunction. The student then needs to troubleshoot the computer.

Faculty

For instruction, the electronics instructors have been retrained. Industrial specialists are also providing related instruction (such as programmers, electronics experts, etc.)

Placement

There are no graduates to date from the program. It is anticipated that those who complete the program will be trained for entry level positions beyond those customarily associated with the basic electronics programs. This includes the following areas: Computer service technician, voting machine repairer, servomechanism technician, electronics technician and/or mechanic and communication technician.

Future Trends

In the future, it is anticipated that automated manufacturing or robotics units will be added to the program.

PROGRAM: Computer Integrated Manufacturing
INSTITUTION: Cincinnati Technical College
3520 Central Parkway
Cincinnati, Ohio 45223
(513)559-1520
CONTACT PERSON: Rob Speckert
DEGREE: Associate Degree in Applied Science
Major in Computer Integrated Manufacturing
(5 terms - 108 credits)
PROGRAM STARTED: Fall 1983

History

The history of the program centers around the education and development of the coordinator. He began pursuing his own interests in CAD/CAM in the fall of 1981. He used computers to monitor and control the business and technical aspects of a company. By the spring of 1982, he offered a course in Computers Applications which was later called Computer Aided Manufacturing I. In the fall of 1982, he became the Coordinator of the Manufacturing program and charged with the responsiblity to move into "High Technology". Several faculty members, along with the coordinator, began working on the concept which later became know as Computer Integrated Manufacturing, a name which was intended to represent the integration of CAD and CAM.

From the fall of 1982 through the fall of 1983, the coordinator and staff developed specific courses and labs that will eventally result in graduates being "computer competent". It is hoped that by the fall of 1984 or early 1985, the department will be simulating a fully automated factory in which students will be exposed to the marketing, planning, engineering, manufacturing and shipping of a product from a system that is totally "computer integrated". According to the coordinator of the program, the initial thrust came from him but the success of the program is based on the collective efforts and professionalism offered by all persons involved in the creation of the program. To him, that is of paramount importance to the success of any project of this kind.

Figures 1 and 2 contain charts which represent the history and the future of the programs.

FIGURE 1

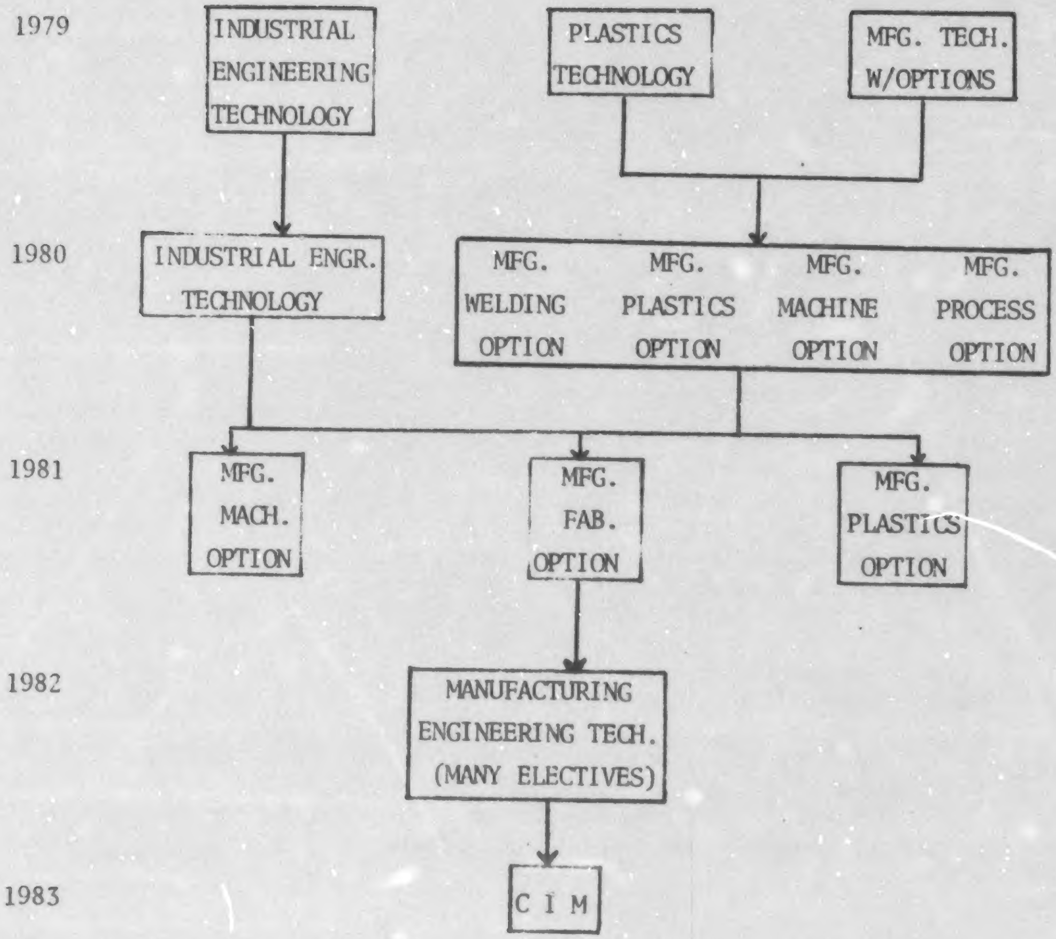

1979
INDUSTRIAL ENGINEERING TECHNOLOGY
PLASTICS TECHNOLOGY
MFG. TECH. W/OPTIONS
1980
INDUSTRIAL ENGR. TECHNOLOGY
MFG. WELDING OPTION
MFG. PLASTICS OPTION
MFG. MACHINE OPTION
MFG. PROCESS OPTION
1981
MFG. MACH. OPTION
MFG. FAB. OPTION
MFG. PLASTICS OPTION
1982
MANUFACTURING ENGINEERING TECH. (MANY ELECTIVES)
1983
C I M

FIGURE 2

		1982							1983					
	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.
DEVELOP PROGRAM OBJECTIVES	-----	-----	-----											
DEVELOP COURSE SEQUENCE		-----	-----	-----	-----									
DEVELOP COURSE OBJECTIVES				-----	-----	-----								
DEVELOP COURSES				-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
PLAN PERSONNEL WORKLOAD	-----	-----	-----	-----	-----	-----	-----	-----	-----					
TRAIN PERSONNEL	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
PURCHASE HARDWARE/ SOFTWARE				-----	-----	-----	-----							
FORM ADVISORY COMM.						-----	-----	-----						
BEGIN ACCEPTING STUDENTS						-----	-----	-----	-----	-----	-----	-----	-----	-----
"ADVERTISE"						-----	-----	-----	-----	-----	-----	-----	-----	-----
PROGRAM "READY"													-----	-----
REVIEW/EVALUATE						-----	-----	-----	-----	-----	-----	-----	-----	-----

MAJOR COSTS	CONCERNS
TRAINING	TOO MANY "NEW" COURSES
HARDWARE/SOFTWARE	TENDENCY TO GET "OFF TRACT" (INTERNALLY)
	NEED SPECIFIC GOALS

Advisory Committee

The advisory committee consists of representatives of area industries. They are responsible for seeing that the curriculum and objectives of the program remain relevant to the job tasks expected of graduates upon completion of the program. A list of their job titles and places of employment will indicate the type of people who were and are integral in determining the direction of this program.

Job Title	Place of Employment
Tool and Process Engineer	Electro-Jet Tool Co.
Manager of Training	Heekin Can, Inc.
Senior Manufacturing Engineer	General Electric Co.
Manager, Manufacturing Engineer	CINCINNATI, Incorp
Manager of Computer Graphics	Kenner Products
CAD/CAM Manager	Hamilton Tool
Numerical Control Manager	Minco Tool and Mold
OPW Division	Dover Corportation
Manager of Manufacturing Engineering	Cincinnati Milacron

Program

The program is a five term program which combines experiences in lecture and the laboratory. In addition, there are recommended electives. A total of 108 credits is needed to graduate. The course by course curriculum follows.

COMPUTER INTEGRATED MANUFACTURING

TERM I	LECTURE	LAB	CREDIT
1001 Communication Skils I	3	0	3
1191 Algebra & Trigonomety I	4	0	4
1512 Microeconomics	3	0	3
2291 Physics I -- Kinematics & Dynamics	3	2	3
7008 Basic Engineering Drawing	2	4	3
7104 Machine Tools & Manufacturing Processes	3	2	3
			--
			19

TERM II			
1002 Communication Skills II	3	0	3
1192 Algebra & Trigonometry II	4	0	4
2292 Physics II -- Mechanics & Heat	3	2	3
7030 Computer Programming (Basic)	2	2	3
7111 Engineering Materials	3	2	3
7144 CNC/NC Programming	2	3	3
			--
			19

TERM III

102x	Speech Elective	3	0	3
1179	Technical Statistics	4	0	4
2293	Physics III -- Electromagnetic Waves	3	2	3
7411	Processes & Materials of Manufacturing	4	2	4
7708	Electrical Fundamentals & Controls	3	3	4
				--
				18

TERM IV

1535	Labor Management Relations	3	0	3
7140	Strength of Materials	4	2	4
7441	Quality Assurance/Quality Control	4	2	4
7449	Computer-Aided Manufacturing I	4	2	4
7443	Manufacturing Methods & Cost Analysis I	3	2	3
				--
				18

TERM V

1010	Technical Writing	3	0	3
15xx	Social Science Elective	3	0	3
7160	Computer-Aided Design/Drafting	2	3	3
7453	Manufacturing Methods & Costs Analysis II	3	2	3
7459	Computer-Aided Manufacturing II	4	2	4
7xxx	Technical Elective			3
				--
				19
				--
				95
			Co-op	13

			TOTAL	108

RECOMMENDED ELECTIVES:

7135 Hydraulics & Pneumatics
7430 Time & Motion
7161 CAD/CAM
7031 Computer Programming (Fortran)
7033 Advanced Computer Applications
7442 Advanced Quality Control

Course outlines for those courses already developed are included. Those courses which are still under development are noted as such.

COURSE OUTLINE

Course Number: 7030 Course Title: Computer Programming (Basic)
Lecture Hours: 2 Technologies: All Engineering Technologies
Lab Hours: 2 Prepared by: Ken Steidley
Credit Hours: 3 Date: 4/24/80
Corequisite: 1191 Revision Date: 12/15/82

I. Course Description

Study of the Basic Programming Language as a vehicle to write on code computer programs. Course is problem solving oriented. Emphasis is on good program design (flow charting and documenting) and efficient, logical coding. Programs will be analyzed, designed and entered by use of a terminal to the computer.
Output will be produced on terminal and printer.

II. Course Objectives

Upon successful completion of this course the student should be able to:

A. Use a computer language (Basic).
B. Students will learn how input is generated for a program.
C. Students will gain practice in logically analyzing elements of a problem and providing computer instructions for their solution.
C. Use of the computer as a tool for a variety of purposes.

III. Course Content

A. Computers and computer languages.
B. Hardware and software
C. Access to computers and system commands.
    1. Hello
    2. Save
    3. Delete
    4. Run
    5. New/Old
    6. List
    7. Replace

D. Introductory problems and program statements
   1. Print
   2. Let
   3. End
   4. Goto
   5. Imput
   6. Read
E. Flow charts and/or algorithms
F. Loops and data statements
   1. If--then--else
   2. For--next--step
G. Alphanumeric string variables
H. Format statements
   1. Tab--Graphic Output with Tab
   2. Print Using
I. Arrays and subscripts - Dim Statements
J. Subroutines and On--GOTO
K. Files

COURSE OUTLINE

Course Number:	7104	Course Title:	Manufacturing Processes
Lecture Hours:	3	Technologies:	MF, MD, EM
Lab Hours:	3	Prepared by:	D. Meyer/R. Speckert
Credit Hours:	3	Date:	6/6/80
Prerequisites:	1171 7008	Revision Date:	12/19/82

I. Course Description

To provide an overview of the precision measuring instruments used within the metals and plastic manufacturing operations. Includes the technical knowledge associated with the operation of metal working equipment and related tooling. Includes plastic, welding, powder metallurgy, hot and cold metalworking processes and equipment. Provedes the student with an understanding of the process time and cost input versus dimensional control output.

II. Course Objectives

Upon successful completion of this course the student should be capable of:

1. Using the more common measuring instruments.
2. To demonstrate knowledge of the various ferrous and non-ferrous manufacturing processes.
3. To identify manufacturing processes as required to complete a finished product relative to production quantities and end product use.
4. To identify the more common metal finishing processes and their applications.
5. To define the various welding and plastic manufacturing processes.
6. To demonstrate a knowledge of finish and dimensional tolerance capability of each manufacturing process.

III. Course Content

A. Precision Measuring Instuments
   1. Types
   2. Applications
B. Machinability
   1. Cutting techniques
      a. Tools
      b. Feeds/Speeds
   2. Finish
   3. Coolants

C. High Production Turning Machines
   1. Types
   2. Applications
   3. Tooling
D. Drilling Machines
   1. Types
   2. Applications
   3. Tooling
E. Milling Machines & Cutters
   1. Types
   2. Tooling
   3. Applications
F. Grinding Machines
   1. Types
   2. Wheel Structure
   3. Application
G. Special Processes
   1. Sawing, Broaching, Shaping, Planners
   2. Welding
   3. Molding (Metal)
   4. Presswork
   5. Non-conventional
      a. EDM
      b. Laser
   6. Plastics

COURSE OUTLINE

Course Number: 7144 Course Title: NC/CNC
Lecture Hours: 3 Technologies: MD, MF, EM
Lab Hours: 2 Prepared by: R. Speckert
Credit Hours: 3 Date: 4/18/80
Prerequisites: 7104
1191

I. Course Description

Introduction to Numerical Control (NC) and Computer Numerical Control (CNC) technology. Emphasis on tape control systems, writing of programs and lab eperience in implementing these programs on a 2-1/2 Axes NC Milling Machine and 2 Axes CNC Lathes.

II. Course Objectives

Upon successful completion of this course, a student should be able to design, write, and "debug" programs for numerical control and computer numerical control applications.

III. Course Content

A. Introduction to NC/CNC
   1. Definition of terms
   2. Applications
   3. Advantages

B. NC Systems
   1. Machine Motions
   2. Programming methods
   3. System Configurations

C. CTC's NC 2-1/2 Axis Mill
   1. Characteristics
   2. Programming
   3. Lab

D. CNC Systems
   1. Control Systems
   2. Programming Methods
   3. System Configurations

E. CTC's CNC 1-1/2 Axis Lathes
   1. Characteristics
   2. Programming
   3. Lab

COURSE OUTLINE

Course Number:	7160	Course Title:	Computer Aided Design Drafting (CAD/D)
Lecture Hours:	2	Techologies:	MD & MF
Lab Hours:	3	Prepared by:	Kenneth Steidley
Credit Hours:	3	Date:	2/16/83
Prerequisites:	7008 7030	Revision Date:	

I. Course Description

A course in Computer Aided Design/Drafting (CAD/D). Use of computer graphics to make, store, copy and alter engineering drawings. Use cost, part numbers, bill of materials and other related data to analyze alternate design.

II. Course Objectives

A. Develop skill in running graphics software to solve design problems.
B. Complete design projects using computer graphics.
C. Evaluate alternate design solutions using computer-based data relevant to the project.

III. Course Content

A. CAD/D Hardware and Software
  1. Components
  2. Companies
  3. Costs
B. What CAD/D can do
  1. Store information (i.e. drawings).
  2. Analyze date generated by drawings.
    a. Geometric properties
      i. volume
      ii. weight
      iii. moments
      iiii. area
    b. Stuctural analysis
    c. fit and clearance
    d. costs
      i. material used
      ii. standard machining
  3. Generate Bills of Material

C. Design Applications
  1. Mechanical
    a. details
    b. layouts
    c. assemblies
    d. pattern development
  2. Electrical
    a. schematic
  3. Hydarulic
    a. process piping
    b. schematics
  4. Facilities Engineering
    a. Floor plans and layout

COURSE OUTLINE

Course Number:	7161	Course Title:	CAD/CAM
Lecture Hours:	2	Technologies:	
Lab Hours:	4	Prepared by:	R. Speckert
Credit Hours:	3	Date	9/19/83
Prerequisites:	7449 7160		

I. Course Description

A project source integrating Computer Aided Design Technology with Computer Aided Manufacturing. Projects will be coordinated by the instructor so as to familiarize the students with the realities of a totally automated factory.

II. Course Objectives

(Presently being developed)

COURSE OUTLINE

Course Number: 7411 Course Title: Processes and Materials of Manufacturing
Lecture Hours: 4 Technologies: MFG
Lab Hours: 2 Prepared by: J. James
Credit Hours: 4 Date: 4/28/83
Prerequisites: 7111

I. Course Description

Designed to acquaint the student with the wide selection of materials, machines and processes available in areas of machining, forming and joining of materials. Computer usage in areas of feeds and speed, material selection, tool geometry and machinabilities of materials will be applied to compile and store pertinent data.

II. Course Objectives

Upon completion of this course the student will be able to recommend methods of fabrication that will be the most feasible in areas of productivity, quality and cost. The student will become familiar with the various machining, forming and bonding concepts which are up to date and which will be of immediate practical value in solving modern day manufacturing problems.

III. Course Content

A. Challenges to Manufacturing
   1. Changes
   2. Safeguards
   3. Challenges
B. Factors Governing Material Selection
   1. Crystal Structure
   2. Properties of Materials
   3. Mechanical Properties of Materials and Design
   4. Alloying elements and their effects on metal properties
   5. Fabricating characteristics of ferrous metals
   6. Copper and copper-base alloy.
   7. Organic materials
   8. Elastomers
   9. The reclamation of rubber and plastic
   10. Composite materials
   11. Data Bases

C. Machining of Metal
  1. Mechanics of metal cutting
  2. Cutting -- tool materials
  3. Tool geometry, computer application
  4. Machinability
  5. Cutting fluids
  6. Metal cutting operations
  7. Feed and speeds

D. Metal Forming Requirements
  1. Formability
  2. Forming processes
  3. Computer applications

E. Joining Requirements
  1. Welding
  2. Brazing
  3. Soldering
  4. Flame Cutting
  5. Resistance welding
  6. Specialized welding processes
  7. Welding design
  8. Adhesive bonding
  9. Mechanical fasteners
  10. Data bases

COURSE OUTLINE

Course Number:	7140	Course Title:	Strength of Materials
Lecture Hours:	4	Technologies:	MD, MF & EM
Lab Hours:		Prepared by:	R. Craigo
Credit Hours:	4	Date:	6/06/81
Prerequisites:	1192 2292	Revision Date:	12/15/82

I. Course Description

Effects of forces and stresses on materials in various forms and configurations found in engineering and mechanical construction. Use of mathematics in analyzing forces, stresses, moments and equilibrium by use of centroids and moments of inertia. Determination of dimensions and material specification. Topics of study include simple, torsional, and bending stresses; deflection and combined stresses.

II. Course Objectives

To provide the student the opportunity, through intuition and reasoning, to relate the physical properties of matter to the geometric properties of form. The science of the mechanics of materials.

III. Course Content

A. Concept of Stress
  1. Simple Stress
    a. Tension
    b. Compression
    c. Shear
  2. Internal Reactions
  3. Working Stress and Factor of Safety
B. Concept of Strain
  1. Deformation and Strain
  2. Modulus of Elasticity
    a. Ductility
    b. Brittle Materials
  3. Poisson's Ratio
    a. Transverse Strain
    b. Longitudianal Strain
  4. Temperature Effects
    a. Thermal Expansion
    b. Thermal Strain
  5. Modulus of Rigidity

- 6. Strain -- Stress in Members
  - a. Members in Parallel
  - b. Members in Series
- C. Torsion
  - 1. Torsional Stress and Strain
    - a. Angle of Twist
    - b. Polar Moment of Inertia
  - 2. Power Transmission by Shafts
- D. Beams -- Shear and Moment
  - 1. Classification of Beams and Loads
    - a. Types of Beams
    - b. Beam Supports
    - c. Beam Theory
    - d. Beam Reactions
  - 2. Shear and Moment Diagrams
  - 3. Relationship Between Load, Shear and Moment
  - 4. Moving Loads
- E. Beam Design
  - 1. Bending Stresses
  - 2. Longitudinal Shear Stress
  - 3. Vertical Shear Stress
- F. Deflection of Beams
  - 1. Methods
    - a. Moment Area
    - b. Slope--Deviation
  - 2. Radius of Curvature
  - 3. Deflection by Superposition
  - 4. Special techniques
- G. Combined Stresses
  - 1. Principle of Superposition
  - 2. Axial and Bending
  - 3. Eccentrically Loading
    - a. Short Compression Members
    - b. Machine Members
  - 4. Combined Bending and Torsion (Brief introduction)
- H. Columns (covered in detail in machine design)
  - 1. Introduction
  - 2. General Considerations

COURSE OUTLINE

Course Number:	7441	Course Title:	Quality Assurance/ Quality Control
Lecture Hours:	4	Technologies:	MF
Lab Hours:	2	Prepared by:	J. James
Credit Hours:	4	Date:	4/28/83
Prerequisites:	1179		

I. Course Description

Survey of various functions, concepts, responsibilities, as they apply to the areas of quality control. Applications of statistics and probabilities to basic quality control problems with emphasis on computer useage to aid in compiling of data. Program written in areas of histograms, control charts and sampling.

II. Course Objectives

Upon completion of this course the student will be able to identify the quality control function as it applies to engineering production, appraisal and administration and computer competency as applied to statistical studies of quality problems.

III. Course Content

A. Quality Control Concept
  1. Total Quality Control
  2. Quality Assurance
  3. Zero Defect
  4. Quality Control Circles
B. The three Quality Control Steps in Inspection
  1. Collect Date
  2. Analyze data, computer compilation
  3. Action on data
C. Aid to Engineering
  1. New design
  2. 1st production run
  3. Required gauges
D. Aid to Production
E. Appraisal Aid
  1. Tolerance Checks
  2. Reliability studies, computer applications
F. Administration
  1. Cost reduction
G. Basic Station Control Inspection
  (Various stations throughout plant)

H. Variations
   1. Time based inspection
   2. Part to part
   3. Operation within part
   4. Histograms, computer applications
I. Probability
   1. Specific approaches
   2. Basic mathematics
   3. Combined
   4. The Addition Law
   5. Randomness
J. Analysis Techniques for Discrete Data
K. Control Charts (Computer Applications)
   1. The p Chart
   2. The c Chart
   3. The u Chart
   4. The D Chart
   5. The Average and Range Charts
   6. Machine Capability Study
   7. Frequency distributions
L. Acceptance Sampling
   1. Sampling Inspection Tables
   2. MIL-STD-105D
   3. Phillips Std. Sampling System

COURSE OUTLINE

Course Number:	7449	Course Title:	Computer Aided Manufacturing I
Lecture Hours:	4	Technologies:	MD, MF
Lab Hours:	2	Prepared by:	Rob Speckert
Credit Hours:	4	Date:	7/9/82
Prerequisites:	7030 7144	Revision Date:	12/15/82

I. Course Description

This course covers the high technology hardware involved with the totally automated factory. Numerical Control (NC), Computer Numerical Control (CNC), Distributive Numerical Control (DNC), Robotics, Flexible Manufacturing Systems (FMS) and other Computer Aided Manufacturing systems are discussed. Computer-Assisted part programming and group technology techniques are introduced.

II. Course Objectives

Upon successful completion of this course the student should be able to:

A. Recite technical terminology related to the field of Computer Aided Manufacturing.

B. Layout the process by which computers in automated manufacturing systems:
   1. Collect on line manufacturing data
   2. Control Machines
   3. Coordinate Manufacturing cells

C. Do a cost analysis and justification for qutomated equipment.

D. Write a simple NC program using a geometry definition macro language.

III. Course Content

A. Computer Assisted part programming

B. Automated Manufacturing systems:
   1. Transfer lines
   2. NC, CNC, DNC
   3. Flexible Manufacturing Systems

C. Robotics
   1. Types of robots
   2. Applications

D. Group Technology
   1. Tooling considerations
   2. Machining cells

E. Automation Considerations
   1. Costs and ROI
   2. The Human Factor

COURSE OUTLINE

Course Number:	7459	Course Title:	Computer Aided Manufacturing II
Lecture Hours:	4	Technology:	MD, CM
Lab Hours:	2	Prepared by:	R. Speckert
Credit Hours:	4	Date:	5/2/83
Prerequisites:	7449		

I. Course Description

This course covers the software systems of a totally automated factory. Techniques for attaining optimum utilization of facilities, equipment and other manufacturing resources are covered; Computer Assisted Process Planning (CAPP), Capacity Requirements Planning (CRP), and Material Requirements Planning (MRP) systems are introduced.

II. Course Objectives:

Upon successful completion of this course, the student should be able to:

A. Develop a group technology data base.
B. Optimize equipment usage through scheduling.
C. Layout a "plant" for optimum "flow"
D. Model a small manufacturing facility and develop a suitable MRP system for that facility.

III. Course Content

A. Group Technology
   1. Development of data bases
   2. Impact on scheduling/layout
   3. Examples and applications
B. Process Planning/Plant Layout
   1. Optimizing equipment usage through scheduling and layout.
   2. Effects of product mix, lot size, demand and work force on scheduling.
   3. Examples and applications
C. Material Requirements Planning
   1. Advantages/Disadvantages of computerized systems
   2. Training requirements
   3. Problems to expect
   4. Examples and applications

7450 - Manufacturing Methods & Cost Analysis I*

Manufacturing practices and planning procedures are introduced with emphasis on manufacturing analysis, cost estimating, quality and tool design. Additional topics include application of methods, production scheduling control and the tolerances required in tool and manufacturing design.

7451 - Manufacturing Methods & Cost Analysis II*

Implementation of the manufacturing plan with emphasis in areas of detail parts, assemblies, testing and packaging. The part/product is processed from its original to finished state by the application of methods, tool and fixture selection, correct sequencing, operation identification and standard time requirements.

*Course presently being developed

Type of Students

As of May 13, 1983, the following students were enrolled in the Manufacturing Technology Program

34	**1st Year Students**
9	Evening School Only
13	On Co-op
6	Eligible & Need Co-op Jobs
2	Do Not Co-op
1	Academic Problems
3	Part Time -- Will Start Full-Time in September 1983
32	**2nd Year Students**
7	Evening School Only
12	On Co-op
3	Eligible & Need Co-op Jobs
8	Do not co-op
2	Academic Problems
9	**IE Students Matriculated This Term**
4	Evening School Only
3	Do Not Co-op
1	Need a Co-op Job
1	Part Time
2	**PL Students Matriculated This Term**
77	Total Manufacturing Technology Students

Equipment

The equipment purchased for the Computer Integrated Manufacturing program includes:

I. Equipment Purchased from Operating Budget

6 - CNC EMCO 5 Trainers (Lathes, Mills)	$8,500.00/each
1 - NC Tape Preparation System	4,000.00/each
2 - Armborg (Miniature Robots)	3,000.00/each
2 - Tektronix 4051 Computers	6,500.00/each
Various Software for Tektronix	1,000.00

II. Equipment Purchased or Donated Through a Resource Development Fund

1 - CNC Turning Center (Cincinnati Milacron Donated)	$160,000.00/value
8 - IBM Personal Computers (for CAD)	3,000.00/each
CAD Lab Furniture	8,000.00
2 - Plotters/2 Printers	5,000.00
CAD Software (Microcad)	3,600.00

III. Other Equipment being used (not recently purchased)
NC Milling Machine
Machine Tool Lab (Mills, Lathes, Grinders, etc.)
Drafting Tables
Various Quality Control Equipment
Related Materials for all Labs mentioned

Equipment currently on order:
4 additional IBM Personal Computers
4 additional Micro Robots

Faculty Development

The coordinator of the program has degrees in Engineering Technology with an Electro-Mechanical major and a Masters in Business Administration with a major in Operations Research. His interest in Computer Integrated Manufacturing was developed through seminars and technical literature. Since then it has become a policy that all new faculty hired in the Mechanical/Computer Integrated Manufacturing area have experience with computers and their application. Faculty members have also had the opportunity to upgrade their training in CAD and NC/CNC.

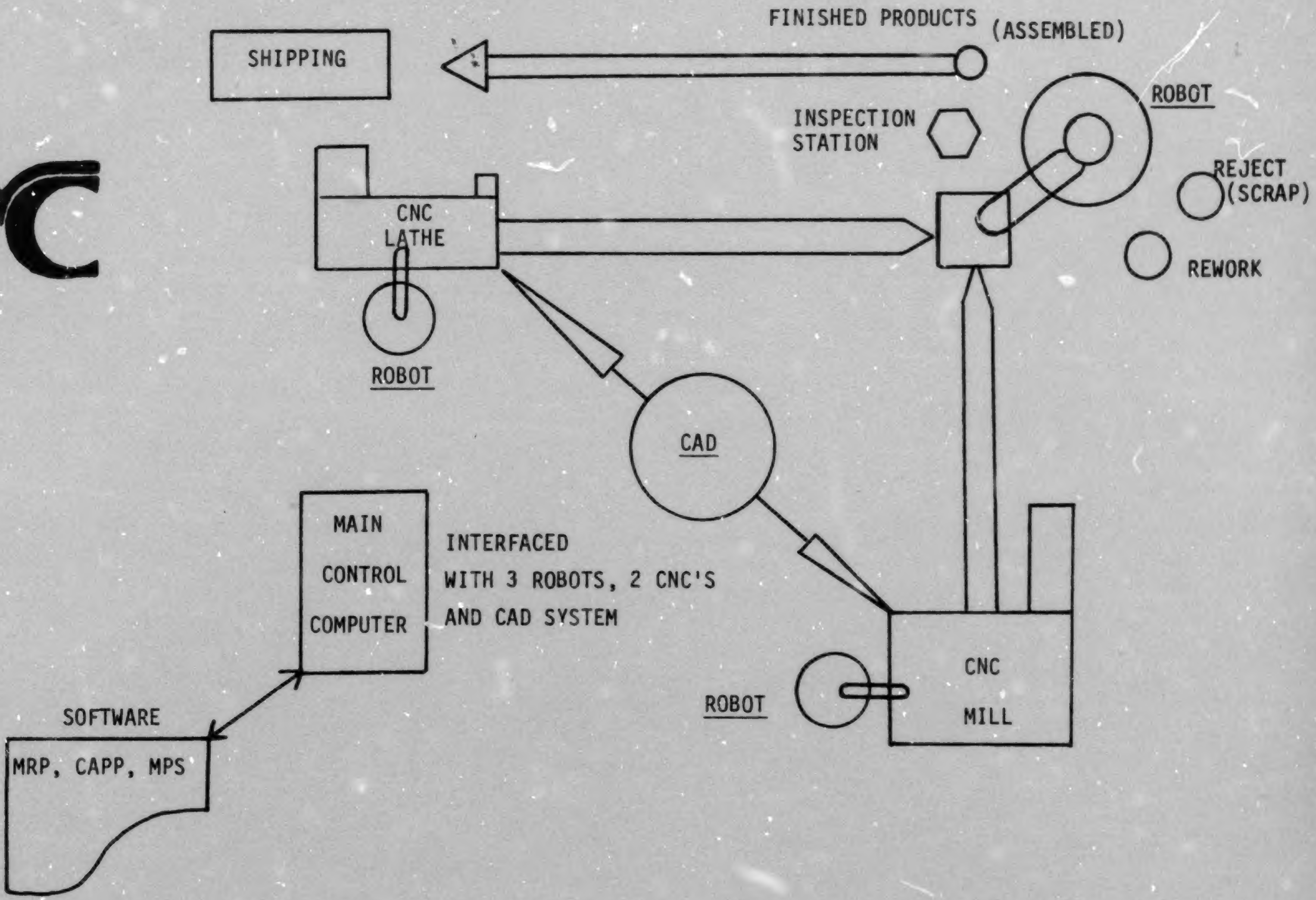
Placement

The program has recently been started so there are no placement records to date.

Future of the Program

By 1985, it is hoped that a totally automated factory will be in place. The design for that factory follows. (See Figure 3.)

FIGURE 3


FINISHED PRODUCTS (ASSEMBLED)
SHIPPING
INSPECTION STATION
ROBOT
REJECT (SCRAP)
REWORK
CNC LATHE
ROBOT
CAD
MAIN CONTROL COMPUTER
INTERFACED WITH 3 ROBOTS, 2 CNC'S AND CAD SYSTEM
SOFTWARE
MRP, CAPP, MPS
CNC MILL
ROBOT

AUTOMATED FACTORY

PROGRAM: Electronic Certificate Program
INSTITUTION: Broward Community College
3501 S.W. Davie Road
Davie, Florida 33314
(305) 475-6683
CONTACT PERSON: Samuel L. Oppenheimer
DEGREE: One-Year Certificate Program (10 months)
Program can also serve as first year of
Associate of Science Degree program

History

Broward Community College responded to the needs of the local electronics industry by beginning a one-year certificate program in Electronics during the 1982-83 academic year. This program was intended to cover the knowledge and skills for entry level electronics technicians. The program was designed for those with no previous training in electronics. Data collected from area employers in Broward County indicated that more than 1000 electronics technicians were needed each year to meet their needs. Further study in defining the need showed that the greatest need was in the area of entry level, "production" technicians. These technicians need a great deal of experience in equipment usage. The amount of theory needed by these technicians is less than that needed for A.S. degreed electronics technicians.

Consultation with industry sources indicated that a one year certificate program would be the most effective way to meet the needs for entry level technicians.

The faculty had an ambivalent attitude towards the program when it first began. However, towards the middle of the first year of the program, faculty were pleased and surprised at both the quality of the learning and the amount of of knowledge learned by the students. The following changes were then incorporated into the program and are now a permanent part of the program.

Program

1. By making the certificate program part of the first year of the A.S. degree program, there is no longer competition for the freshman students between two programs.

2. This change also eliminates the need for additional faculty to teach courses that are essentially parallel.

3. Those students that complete the first year have employable skills. They may then elect to go to work, and complete the A.S. degree by attending evening courses.

4. Students from selected area vocational centers who have completed the Computer Electronics program may enter the A.S. program with 24 transfer credits. This benefits BCC

by giving them a new source of second year students at the time when some of the first-year completers leave BCC.

5. The program change allows them to require applied calculus for all A.S. degree students in Electronics. This does qualifies BCC for ABET accreditation. ABET is analogous to ABA accreditation for a law school, AMA for a medical school, etc.

a. BCC recognizes that discrete circuits are no longer as important as in the past, and that the future is n the form of linear integrated circuits. Accordingly, they introduced two courses, ETE 1140 and ETE 2146, to replace ETE 2141C, 2150, and ETE 2145C. Total credits are the same in both cases. What is changed are the topics that are emphasized and the amount of time devoted to laboratory assignments.

b. The other change is the addition of ETE 2020, Circuit Analysis. This is a rigorous, highly analytical course on network theory, filters, and oscillators. It contains some material that used to be in the first year A.S. course-work, but most of its content is too advanced to be taught in the first year.

The first year of the program was originally established for non-traditional students, particularly the displaced homemaker. They were full-time students in the program. The hours of their classes and labs were scheduled around public school hours so that attendance was not a problem.

Currently, the program is held during days and nights. All evening students come at least two times a week. If students attend during the day, it takes them one year to complete the program. If they attend at night, it could take two years or longer.

There are no prerequisites for the program. Courses are structured around a combination of lectures and laboratory assignments There is an emphasis on simulated problem-solving so that the problems that appear at the work site will be familiar to all those that complete the program.

The course content for the program and course descriptions follow.

ELECTRONICS CERTIFICATE PROGRAM

First Term:

IA: ETE 1001C Circuits.....................5
IB: ETE 1002C A.C. Circuits................5

Second Term:

IIA: ETE 1141C Basic Electronics............5
IIB: ETE 1600C Digital Techniques...........5

Term IIIA

ETE 1004C Microprocessors....................4

This program is designed for early job entry for those with no previous training in electronics. Utilization of the IMTS Center is recommended for those requiring remediation in basic skills.

B.C.C. Course Title: D.C. Circuits

Common Course Number ETE 1001C 5 Credits

I. Course Objective: The objective of this course is for the student to gain an understanding of the definitions and relationships of voltage, current, circuits and circuit elements.

II. List of unit titles:

Unit #1: Fundamental Definitions and Relationships
Unit #2: Series and Parallel Circuits
Unit #3: Reactive Elements and Circuits
Unit #4: Practicum

V. Basic Text Book: Fundamentals of Electric Circuits, Oppenheimer

VI. Special Student Projects:
See Unit #4

VII. Corequisites:
None

Unit #1: Fundamental Definitions and Relationships

The student will learn the definitions and relationships of current, voltage, resistance, power and energy.

1. Current (definition)
2. Voltage (definition)
3. Resistance (definition)
4. Ohms law. ($V = IR$)
5. The student will learn that electrical power is the product of voltage and current, the product of current squared and resistance, or the quotient of voltage squared and resistance.
6. The student will learn that electrical energy is power times time.

Unit #2: Series and Parallel Circuits and Networks

The student will learn how to apply Kirchhoffs' Laws to solve for unknown voltages and currents in series, parallel and series-parallel circuits.

1. Kirchoffs' Voltage law and the voltage divider rule.

2. Kirchoffs' Current law and the current divider rule.

3. The student will learn to analyze series-parallel circuits.

Unit #3: Reactive Elements and Circuits

The student will be able to compute the voltage across a capacitor after charging for a disignated period.

1. The student will be able to compute the voltage across a capacitor after charging for a designated period.

2. The student will learn the duality of magnetic circuits and electric circuits.

3. The student will learn to compute the L/R time constant and compute the energy stored in an inductor.

Unit #4: Practicum

The student will be able to properly use meters to verify circuit performance.

1. The student will be able to properly measure resistance.

2. The student will be able to properly measure voltage.

3. The student will be able to properly measure current.

B.C.C. Course Title: A.C. Circuits

Common Course Number: ETE 1002C 5 Credits

I. Course Objective: Course shall provide the student with a background in alternating currents and voltages and reactive circuits, frequency response, and transient response. The laboratory experience will be with signal sources, dual trace-dual time base oscilloscopes and circuits.

II. List of Unit Titles

Unit #1: A.C. Voltages and Currents

Unit #2: Circuit Analysis

Unit #3: Transient Response

Unit #4: Passive Filter Circuits

Unit #5: Resonance

III. Basic Textbook:

Fundamentals of Electric Circuits, Oppenheimer

IV. Pre-Requisite -- ETE 1001C - D.C. Circuits

Unit #1: A.C. Voltages and Currents

The student will learn the definitions and relationships of various types of A.C. wave-forms, phase relations, effective values and understand the types of computations necessary in alternating current circuits.

1. The student will learn about the various types of alternating voltages and currents such as pulse waves, square waves, saw tooth waves, triangular waves and sine waves.

2. The student will learn the meaning of frequency.

3. The student will learn the meaning of period and the mathematical relationship between frequency and period.

4. The student will learn the meaning of effective value of a sine wave.

5. The peak-to-peak value and peak value of any wave.

Unit #2: Circuit Analysis

The student will learn how to apply network theorems and method of analysis to series, parallel, and series parallel A.C. circuits.

1. Student will learn how to calculate inductive reactance and understand the relationship between inductive reactance and frequency.

2. The student will learn how to compute capacitive reactance and understand the manner in which reactance varies with frequency.

3. The student will calculate a series R-L and R-C circuits.

4. The student will calculate series RLC circuits.

5. The student will solve problems in parallel circuits.

6. The student will solve problems in series parallel circuits.

Unit #3: Transient Response

1. The student, working with appropriate signal sources, will do experiments in the pulse response of R.C. circuits.

2. The student shall understand R.C. differentiators.

3. The student shall understand R.C. integrators.

4. The student shall perform laboratory experiments determining the pulse response of R.L. circuits including differentiators and integrators.

Unit #4: Passive Filter Circuits

1. The student shall learn the response characteristics of low-pass, high-pass and band pass filter.

2. Using the appropriate equipment, the student shall run tests on R.C. low pass filters, observing how the break point frequency is affected by the time constant.

3. In a similar manner students shall perform experiments on high pass filters.

4. Students shall use a combination of high and low pass filters to form band pass filters, observing once again the affect of the time constants on the band pass.

Unit #5: Resonance

The student will learn how series and parallel resonance may occur and how to determine circuit component values for a specific resonant frequency, the effect of circuit Q on bandwidth, circulating current, and the Q rise of voltage across each reactance in a series resonant circuit.

1. The student will analyze series resonant circuits.

2. The student will analyze parallel resonant circuits.

3. The student will observe the effects of resistance upon circuit Q, in particular the effect upon bandwidth.

4. The student will perform laboratory projects relating resonant frequency bandwidth and Q.

B.C.C. Course Title: Introductory Electronic Circuits

Common Course Number: ETE 1141C 5 Credits

I. Course Objective: Students will learn the basics of amplifiers and power supplies, with emphasis upon operational amplifiers. (This course combines lecture on general concepts only, with laboratory experience on actual circuits. Students will study some of the properties of discrete devices in order to begin understanding schematic diagrams.)

II. List of Unit Titles:

Unit #1: Elementary Amplifiers

Unit #2: Operational Amplifiers

Unit #3: Rectifiers and Power Supplies

V. Textbooks:

Electronic Circuit Behavior, Metzger

VII. Pre or Co-requisites:

ETE 1001C, 1002C

Unit #1: Elementary Amplifiers

The student will learn the following properties of amplifiers. Laboratory experience on bipolar junction transistors will be the only place where study of discrete amplifying devices shall occur.

1. Definitions and terms:
   a) voltage gain
   b) current gain
   c) power gain

2. Input and output impedance

3. Distortion
   a) harmonic
   b) frequency

4. Types of amplifiers
   - a) according to frequency range
   - b) voltage amps
   - c) single ended
   - d) push-pull
   - e) power amps

5. Coupling methods
   - a) R-C
   - b) Transformer
   - c) Direct

6. R.F. Amplifiers

Unit #2: Introduction to Operational Amplifiers

The student will learn the characteristics of operational amplifiers and circuits.

1. Characteristics of ideal op-amps.

2. Characterists of non-ideal op-amps.

3. Inverting and non-inverting circuits.

4. Gain calculations in both types.

5. Understand the operation of the following circuits:
   - a) Comparators
   - b) Differential Amplifiers
   - c) Detectors
   - d) Summing circuits
   - e) Voltage follower
   - f) Active filters

6. Op-amp oscillator circuits
   - a) Wein bridge
   - b) Astabel Multivibrator

Unit #3: Rectifiers and Power Supplies

The student will learn the properties of rectifiers, filtered and regulated power supplies.

1. Diode properties
2. Half-wave rectifiers
3. Full-wave rectifiers

   Biphase
   Bridge

4. Basic Filter Circuits and Ripple
5. Voltage regulation

   Shunt regulator
   Series regulator

B.C.C. Course Title: Digital Techniques

Common Course Number: ETE 1600C 5 Credits

I. Course Objective: The objective of this course is for the student to first learn the binary number system and pertinent codes and procedures and then apply this knowledge with combinational logic and then sequential logic.

II. List of Unit Titles:

Unit #1: Number Systems

Unit #2: Digital Logic Gates

Unit #3: Combinational Logic Circuits

Unit #4: Sequential Logic Circuits

Unit #5: Memory Devices

V. Basic Text Book:

Digital Logic Fundamentals, Thomas L. Floyd -- 2nd Edition

VI. Special Student Project: Each student is required to build, test, demonstrate and report on a device or circuit of their choosing that is pertinent to the contents of this course.

VII. No Co-requisites or Pre-requisites

Unit #1: Number Systems

The students will be able to:

1. Describe positional notation used with binary, octal, and hexadecimal numbers.

2. Add binary numbers.

3. Subtract binary numbers using the 1's and 2's complement methods.

4. Perform conversions from binary to decimal.

5. Perform conversions from decimal to octal.

6. Perform conversions from binary to octal

7. Perform conversions from decimal to hexadecimal.

8. Perform conversions from hexadecimal to binary.

9. Describe the purpose and content of selected special codes used with digital systems.

Unit #2: Digital Logic Gates

The student will be able to:

1. Describe the operation of special semiconductor devices used for implementing digital functions.

2. Identify the following logic gates when provided with their symbology:

a) AND Gate
b) OR Gate
c) NAND Gate
d) NOR Gate
e) Exclusive OR Gate
f) Exclusive NOR Gate
g) Logic Inverter

3. Construct a truth table that describes the function of the following logic gates:

a) AND Gate
b) OR Gate
c) NAND Gate
d) NOR Gate
e) Exclusive OR Gate
f) Exclusive NOR Gate
g) Logic Inverter

Unit #3: Combinational Logic Circuits

The student will be able to:

1. Describe the operation of all the following logic circuits:

   a) Binary Adders
   b) Binary Subtractor
   c) Digital Comparators
   d) Parity Generators/Checkers
   e) Decoders/Demultiplexers
   f) Data Selectors/Multiplexers
   g) Encoders

2. Demonstrate the ability to isolate a malfunctioning device in a multigate combinational logic circuit.

Unit #4: Sequential Logic Circuits

The student will be able to:

1. Describe the operation of the Set-Reset, J - K, T - Type, and D - Type flip flops

2. Construct truth tables for the Set-Reset, J - K, T - Type, and D - Type flip flops.

3. Describe the effect of preset and clear inputs to flip-flops.

4. Determine if a flip-flop will be triggered on the leading-edge or trailing edge of its clock input from its schematic representation.

5. Describe the operation of selected shift registers.

6. Describe the operation of the following counter circuits:

   a) Asynchronous Counters
   b) Synchronous Counters
   c) Up/Down Counters
   d) Shift Counters
   e) MOD -3, 5, 10 Counters
   f) Ring Counters

7. Demonstrate the ability to isolate malfunctions in sequential logic circuits.

Unit #5: Memory Devices

The student will be able to:

1. Describe the differences between volatile and non-volatile memories.

2. Describe the characteristics of magnetism that allow magnetic devices to be used for memory circuits.

3. Describe the operation of the following Read Only Memory (ROM) devices:

   a) PLAs
   b) PROMs
   c) E PROMs
   d) EAROMs

4. Describe the operation of the following Randon Access Memory (RAM) devices:

   a) Static RAM devices
   b) Dynamic RAM devices

B.C.C. Course Title: Microprocessors I

Common Course Number: CDA 2040C 4 Credits

I. Course Objective: The student will learn the fundamentals of microprocessors; programming concepts, chip content, register operations, microprocessor applications and troubleshooting.

II. List of Unit Titles:

Unit #1: Microprocessor Fundamentals

Unit #2: Introduction to Programming

Unit #3: Basic Hardware Concepts

Unit #4: Software

Unit #5: Troubleshooting Microprocessor Systmes.

VII. Pre-requisites:

ETE 1001C, ETE 1002C, ETE 1141C, ETE 1600C

Unit #1: Microprocessor Fundamentals

The student will be able to:

1. Describe the basic concepts of programming

2. Explain the relationship between software and hardware that exist in a microprocessor system.

3. Demonstrate the ability to properly operate a microprocessor trainer in accordance with instuctions contained in its training manual.

Unit #2: Introduction to Programming

The student will be able to:

1. Describe the basic function of the microprocessor system

2. Describe the function of microprocessor register.

3. Describe the purpose of subroutines and the basic instruction associated with them.

4. Describe the purpose of interrupts and how they will effect microprocessor operations.

5. Describe the sequence a microprocessor uses to execute a program.

6. Describe the function of the following:

    a) Arithmetic and Logic Unit (ALU)
    b) Temporary Registers
    c) Flag Registers
    d) Instruction Registers
    e) Instruction Decoders
    f) Program Counters

Unit #3: Basic Hardware Concepts

The student will be able to:

1. Describe the purpose of the Tri-State Bus.

2. Describe the purpose of the Data Bus.

3. Describe the purpose of the Address Bus.

4. Describe the purpose of the Control Bus.

5. Describe the techniques used for address decoding.

6. Explain the differences between Memory Mapped I/O and I/O Mapped I/O.

7. Describe the difference between ROM and RAM semiconductor memory.

8. Describe the purpose of microcomputer peripherals.

9. Describe the operation of multiplexed control lines and buses.

10. Describe the purpose of the following input signals used with microprocessors:

    a) Clock
    b) Reset
    c) Interrupts
    d) Hold/Hold Acknowledge

11. Define Direct Memory Access (DMA).

Unit #4: Microprocessor Software

The student will be able to:

1. Describe the purpose of the microprocessor general purpose registers.

2. Define Breakpoints.

3. Use breakpoints in a program to facilitate program debugging.

4. Describe the functional groups of instructions contained in microprocessor instruction sets.

5. Demonstrate the ability to design and flow-chart a functional program.

6. Describe methods used to extend the range of numbers a microprocessor can process.

7. Describe how decimal numbers and alphanumeric symbols are represented in a binary-oriented processor system.

8. Describe how complex mathematical functions are performed by microprocessors.

Unit #5: Troubleshooting Microprocessor Systems

The student will be able to:

1. Demonstrate the ability to use logic probes, logic pulsers, and current tracers to troubleshoot microprocessor systems.

2. Demonstrate the ability to use a logic analyzer to troubleshoot microprocessor systems.

3. Demonstrate the ability to use a logic analyzer to troubleshoot microprocessor systems.

Faculty

The faculty are the same as those that teach in the electronics program. They are all degreed electrical engineers.

Placement

Those who complete the program may enter a career in computers, robotics, avionics, biomedical, communications or research and development. With a certificate of completion, graduates will generally enter the entry level technician position. Feedback from area employers indicates that graduates can expect to earn a starting rate of approximately $7.50 per hour.

To date, there is one class that has completed the program. Of that group 80% have been placed in a related position.

COMPUTER-ASSISTED DESIGN/DRAFTING

Computer-Assisted Design (CAD)

The computer is also revolutioning engineering design tools. Traditional pen and pencil drawings are being replaced by Computer-Assisted Design (CAD), computer graphics for designing and drafting. CAD is used by architects, engineers, product designers and graphic artists. It can be used for business graphics, map-making, geological studies, image processing, aerospace design, electronic circuitry design, etc.

CAD allows designers to enter geometric data of a product. The object resulting from this data appears on the screen. It can then be rotated, enlarged, and/or shrunk, making it possible to view and study all segments of the design. CAD also allows designers to:

-complete on-screen stress tests,

-determine numerable calculations on the design before it even leaves the screen,

-identify and correct design errors before the product is actually made, and

-keep a data base of design parts so that designs which use identical components can access those parts from a data base rather than redesigning each part every time it has to be used.

Employment in CAD

According to the January 1982 issue of Electronic Design, 7500 CAD work stations had been installed by 1980. That number is expected to grow to 75,000 by 1985.

Workers in this field have replacd their drawing boards with computer graphics design stations. The designer needs to have a background in an engineering discipline such as mechanical, electrical or civil. Those employed will also need the knowledge necessary for utilizing CAD equipment.

Education and Training

What skills are necessary in the training of a CAD operator? To begin, the same basic skills needed to succeed as a draftsperson are also needed for Computer-Aided Design.

According to Fisher and Tallerico (1983) The following skills need to be taught in a CAD course and/or degree program:

1. Vocabulary - A new vocabulary and terminology is used by the system operator.
2. Reading - It is necessary to read and comprehend instructional manuals that accompany both the hardware and software.
3. Problem Solving - Students need to be able to assess problems when they arise and then be able to follow a sequential pattern to solve those problems. In addition to solving problems, the user must have the ability to follow directions.
4. Recordkeeping - Because the computer will be storing volumes of information, the user needs to understand how to develop a recordkeeping system which will enable him/her to retrieve information from storage.
5. Keyboarding - Volumes of commands and information are given to the computer through the use of the keyboard. Skills which enable the user to communicate with the computer through the keyboard are critical.
6. Care and Use of Equipment - Students should understand the importance of handling pieces of precision equipment with care and efficiency.
7. Abstract Reasoning - The student should be able to assess a problem, evaluate its limitations and

solutions, and then follow a logical course of action to achieve the desired results.

8. Using Scales - Understanding scaling techniques and their proportional values is necessary for drawing an object and reproducing it to the size and scale commonly used in industry.
9. Grid Usage - The application of the grid system and its relation to units of measurement are a necessity. The student must be capable of choosing grid sizes, divisions, and increments and then utilize them to produce a proportional drawing.
10. Hand Eye Coordination - Utilization of the system requires coordination of the hand and eye. Monitors, digitizers, menus, and keyboards are items that must be manipulated concurrently.
11. Mathematical Skills - The use of math is a necessary part of inputting information into the data bank. Lines, circles, arcs, etc. are put into the computer by means of cartesian and polar coordinates. An understanding of basic algebra helps the student.
12. Grammar - Understanding the proper use of grammatical structure is a necessary skill. Data input is organized into a structure of verb-noun-modifier. The sequence must be followed in a true grammatical structure in order for the CPU to process the command.

References

Fisher, Harvey and Joe Tallerico The Use of Computers in Vocational Instruction: Computer Assisted Design Arlington, Virginia: American Vocational Association, 1983

Selecting the Right CAD System

(Appeared in Technical Education News, Spring 1983)

The decisions and potential pitfalls involved in selecting a CAD system are often confusing and at times frustrating. Since there is a wide range of CAD system capabilities as well as a wide range of costs, finding the most cost-effective CAD system to meet your needs requires careful investigation of each system's features.

To help in this decision-making process, the following questions were developed by CAD experts to provide guidelines for evaluating CAD systems. In addition to seeing a live CAD demonstration, the answers to these questions should give you a revealing profile for comparison of CAD systems within similar price ranges.

Here is a helpful list of questions you can use when comparing CAD systems for instructional applications.

1. How extensive is the symbol library? If limited or none, the system cannot be considered CAD.
2. How automatic is the dimensioning capability? If extension and dimension lines, arrowheads, and numerals are placed individually, then the program is not much improvement over pencil and paper.
3. Can metrication of dimensions be converted automatically and optionally displayed in dual form? If not, what is the dimensioning advantage of the system?
4. Is there an optional near grid intersection lock system with capacity for changing grids to any scale?
5. How many line weights are possible? If only one, final drawings cannot adhere to ANSI standards. Also, the plotter should have at least five pen widths.
6. Can the system easily delete, edit, and move lines, arcs, circles, or text as desired by the user?
7. Can architectural, electrical, electronic, mechanical, or piping drawings be prepared? If not, a different type of system will be necessary to prepare some drawings, duplicating base hardware costs.
8. Are CAD skills learned on the system transferable to most main frame CAD systems? If not, what have students learned?
9. Can the system be used with any size plotter? If not, what are the size restrictions?
10. How is section lining applied? If one line at a time, what is the advantage over paper and pencil methods?
11. Do 3-D drawings show solid hidden lines? If so, how easily or automatically can any hidden lines be removed? Does this take longer than drawing by conventional methods? If hidden lines show, object shape may be indistinguishable except for very simple cubes.

12. Can drawings be prepared to any customary (fractional or decimal) or metric scale? If not, what are scale restrictions?

13. How many levels (overlays) are possible? If too few, preparing sets of drawings will be cumbersome and time-consuming.

14. Are there adequate instructional materials provided which are keyed directly to the system?

15. How complete is the documentation?

16. Are there networking capabilities? Is there a price advantage for networking?

17. Can drawing groups be created, stored, and retrieved easily?

18. Does the system have multiple repeat zoom capabilities? If not, large drawings become difficult to read on the monitor.

19. Can master libraries be conveniently created, stored, and retrieved?

20. Is the system capable of developing bills of materials and specifications directly from the drawing data? If not, an important advantage of CAD is missing.

21. Are drawings lost if the system is electrically disconnected?

22. Is the system used by professionals in industrial settings.?

23. Can other software programs, such as accounting, structural calculations, word processing, etc., be used with system hardware?

24. What future commitments has the vendor made to update and produce new applications, software, and related instructional materials?

25. How reliable is the vendor? How much and what quality of service can be anticipated?

26. How expensive are additional stations compared to the initial station? Are there any hidden costs involved?

27. How does the price compare with systems of compatable sophistication?

28. What provisions are made for teacher training? What does training cost?

29. Is installation provided? By whom is the system installed?

30. How adequate and reliable is the guarantee?

31. Is there a full service maintenance agreement available?

32. Does the color and intensity of the screen display allow maximum comfort for the user?

33. What is the quality of the final drawing compared to other system drawings produced on the same plotter?

34. How complete or deep is the system? How many disks are needed to store the program? How many lines of code are in the program?

35. Does the vendor provide a phone number for immediate technical assistance?

36. How are alpha-numeric notations presented? If presented on the same screen with drawings, drawings will be obstructed as data increases and covers drawings.

37. Does the 3-D capability include perspective or only isometric?

If you develop additional questions in your search for the right CAD system, please send them to the Editor, Technical Education News, 1221 Avenue of the Americas, New York, NY 10020. We would like to share them with your colleagues.

Goals and Objectives for a Postsecondary CAD Course

(Appeared in Technical Education News, Spring 1983)

Editor's note: The following list was prepared at Cerritos College, Norwald, California, for an introductory CAD course. The course at Cerritos consists of two hours lecture and six hours of lab work per week. One year of college-level drafting is required as a prerequisite. Cerritos used eight Cascade II CAD workstations connected through a network to a central fixed disk.

The list provides excellent guidelines for drafting instructors who are preparing their first CAD course.

The student will:

A. Have a general understanding of CAD operations (10 hours)

  1. Recognize and define the principle terms used in CAD
  2. Outline a basic system for putting a drafting problem into CAD format
  3. Understand the tasks involved in utilizing a CAD system
  4. Understand the differences between major types of CAD systems used in industry today

B. Be able to start up and stop the CAD system properly (2 hours)

  1. Turn on the terminal and monitor
  2. Use the disk system to store work done on the terminal
  3. Turn off the terminal and shut down the system

C. Have a working knowlege of steps required for initializing commands to the CAD system using the keyboard (10 hours)

  1. Establish coordinates, either relative, absolute, or polar
  2. Establish the pen number for the plotter when hard copy is desired
  3. Initiate drawing definition utilizing the various levels available
  4. Initiate and turn off grids

D. Have a working knowledge of the steps required for initializing commands for the CAD system using the stylus (8 hours)

   1. Properly handle the stylus on the digitizer board for maximum accuracy and fault-free operation
   2. Coordinate the movements of the cursor on the terminal screen by inputting the following modes: grid pick, free pick, non-axis lock, and axis lock
   3. Use the stylus and board for inputting the following modes: grid pick, free pick, non-axis lock, and axis lock

E. Have a thorough knowlege of the start-up procedures for the system (2 hours)

   1. Gain access to the system using proper coding procedures
   2. Initialize a new drawing using default parameters
   3. Initialize a new drawing using user-specified parameters
   4. Retrieve a stored drawing

F. Be able to use the software hierarchy for operating the system (10 hours)

   1. Input proper commands for the various menus available
   2. Use each menu properly for the task designated
   3. Recognize and apply procedures for creating libraries of desired information

G. Be able to apply the text-editing capability of the system to numbers, letters, or text (10 hours)

   1. Create vertical columns or horizontal rows of text
   2. Construct and justify new drawing text
   3. Examine and edit existing text

H. Be able to generate basic geometric constructions using primary and auxiliary menus (15 hours)

   1. Construct lines and create string figures
   2. Construct arcs and circles
   3. Create fillets and chambers
   4. Create flow lines
   5. Create lines with tangent arcs
   6. Define curves

I. Understand and be able to perform various tasks associated with editing, aligning, and grouping (10 hours)

1. Perform the operations of MOVE-COPY-DELETE
2. Edit arcs
3. Rotate scale
4. Copy and repeat
5. Edit lines
6. Align objects
7. Create, get, and file groups
8. Perform tasks associated with renaming or deleting groups filed in drawing or master library
9. Edit or place groups

J. Be familiar with the procedures for activating the digitizing of existing drawings (5 hours)

1. Determine the digitizing area
2. Determine monument points for defining location of traced input.
3. Activate the command menu
4. Input necessary coordinate points for digitizing the drawing

K. Create drawings using various menus (60 hours)

1. Develop basic orthographic views of parts as assigned
2. Develop dimensioning for drawings
3. Create and input desired crosshatching
4. Widen selected multi-segment lines
5. Develop basic architectural plan examples
6. Develop basic electronic schematic diagram examples
7. Develop basic piping diagram examples

L. Be able to utilize functions associated with the size of the objects on the screen (1 hour)

1. Perform the zoom task
2. Perform the full window task
3. Perform zoom-in 2x and zoom-out 2x

M. Be able to command the system to create a fast-plot of any currently active drawing in the system (1 hour)

1. Use the menu to select desired line widths and color scheme
2. Load the paper desired for use into the plotter
3. Use the menu to plot the drawing
4. Use the menu to change the scale of the drawing to suit the plotter's physical capabilities

INTEGRATING COST-EFFECTIVE COMPUTER AIDED DESIGN (CAD) INTO TECHNICAL PROGRAMS

Victor Langer
Milwaukee Area Technical College
Milwaukee, Wisconsin

Introduction

Is low-cost CAD training in engineering and technical colleges possible through industrial donations? How many students can be served with a four-station turnkey CAD system? Milwaukee Area Technical College (MATC) faced the challenge of high-cost high-tech CAD/CAM education with hardware/software donations and a three year National Science Foundation CAUSE program grant to integrate CAD into technical education, and, with the assistance of industrial partners, developed a competency-based generic 2-D CAD course, advanced CAD courses, an updated faculty, a supportive staff, open laboratory, and a microcomputer CAS emulation to provide low-cost CAD education.

CAD Systems Laboratory

Industry Simulated Laboratory

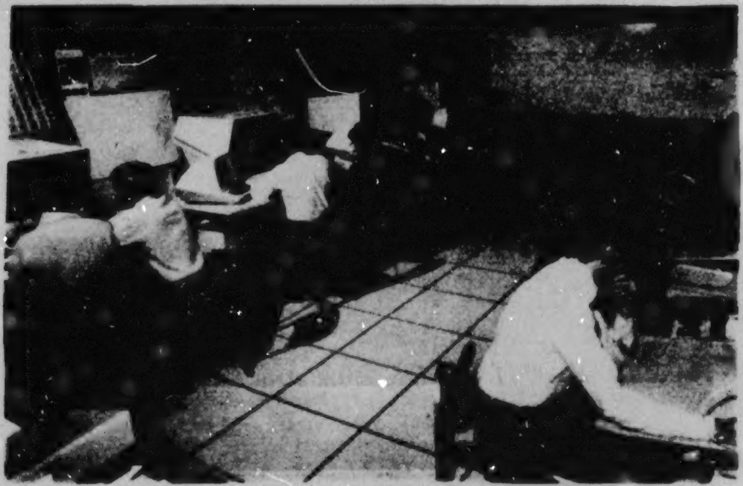
Colleges will attract students and provide job placements with up-to-date experiences and quality instruction. The investment in current technology must complement the first priority, that of instruction. MATC, with over 70 years of providing quality technical education, has maintained an occupational learning environment typical of the industry. For example, when Public Broadcast Station licenses were first granted, MATC, in 1957, sought and obtained the only two channels still operating today in Southeastern Wisconsin. A major television station became a real laboratory for students in Telecasting and Electrical Technology--Communications programs. When CAD/CAM became a needed skill in the community, MATC again sought to obtain a laboratory typical of the industry. A thorough study was made of the hardware/software options, including timesharing or stand-alone systems. It was concluded that the most efficient method would be to begin on a turnkey system (hardware and software package). Also, it was important in an open lab situation to be able to run the different software packages for Mechanical, Electrical, Architectural, etc., all at the same time. Some systems were ruled out because of this limitation. The problem became cost, not software. On the grounds of practicality, how could installation of a $300,000 system with only two design stations, plus the cost of added facility, staff, and maintenance be justified?

Acquiring CAD System

How does a college obtain the support of industry in providing equipment and in meeting other high costs involved? The first step at MATC was to determine the instructional needs, with the help of industrial advisors and faculty. Secondly, the details of an implementation plan were developed which included selecting a system, designing a facility, suggesting supportive staffing, developing priorities, and negotiating with vendors. The third step was to provide institutional commitment with a faculty training program, designated curriculum areas, designated responsible staff, facility availability, and some budget money available to engage in serious vendor negotiations. Fourthly, we established a public relations program with the assistance of industrial supporters to show vendors the advantage of installing a system at MATC. Finally, we were willing to start with anything to begin to show results which would justify all the previous planning and become the basis of future expansion.

MATC CAD System

Computer graphics at MATC consists of two complete Computervision systems, two Cadlinc systems, and MATC MICRO CAD systems designed as follows:



Students in MATC Computer Graphics Laboratory using Computer Aided Design and Drafting System (CADDS) stations by Computervision Corporation.

Computervision--Is the nation's largest supplier of turnkey CAD/CAM systems, and as a partner of MATC provided: (1) Designer IV - CADDS 3 with CGP100 processor, 80 meg disc drive, tape drive, 4 storage tube design stations, large surface digitizer and Interact IV Digitizer/Plotter. (2) Designer V - CADDS 4 with CGP200 processor, 300 meg disc drive, tape drive, 2 Instaview (refresh) design stations, 2 Instaview (refresh color) design stations. (3) Software - Mechanical Design and Drafting, Mass Property, Finite Element, Autohide, NC Machining, NC Post Processor, Flat Pattern Layout, Printed Circuit Design Specs, Data Extract/Data Merge, Printed Circuit (PC) Electrical Schematic Design Rules Checking, PC Design NC Component Insertion, PC Autoroute, PC Autoplacement, PC Geometric Checking, PC Netlist Extraction and Verification, PC IPC Translator, PC Wirewrapping Interface, PC Schematic and Library, Wiring Diagrams, PEP, FORTRAN, I.G.E.S., VARPRO 2, and a commitment for all architectural, robotics, and other new releases.

MATC Cadlinc System

Cadlinc--Emerging as a leader in offering low-cost networked micro systems for design and manufacture of machined parts, and as partner provided MATC with: Hardware: two workstations, each unit with a stand-alone computer (Motorola 68000 micro processor) with one megabyte memory and 10 megabyte hard disc. Software: Graphic Numerical Control (GNC) Surface Modeler, and Design Drafting and Detailing (DDD).

MATC MICRO-CAD (TM)--Was developed at MATC to reduce the cost of design stations permitting use of the Computervision and Cadlinc systems for advanced courses. MICRO-CAD is designed to be used primarily as an educational tool for teaching the basic elements of computer-aided drafting in the introductory course. The software is based on an emulation of most of the general two-dimensional capabilities of Computervision's CADDS-3 (TM) graphics system and uses the same student training manual. Hardware: standard Apple II Plus or IIE microcomputer, graphics tablet, two floppy discs and a green phosphor monitor with no modifications. Software features include:

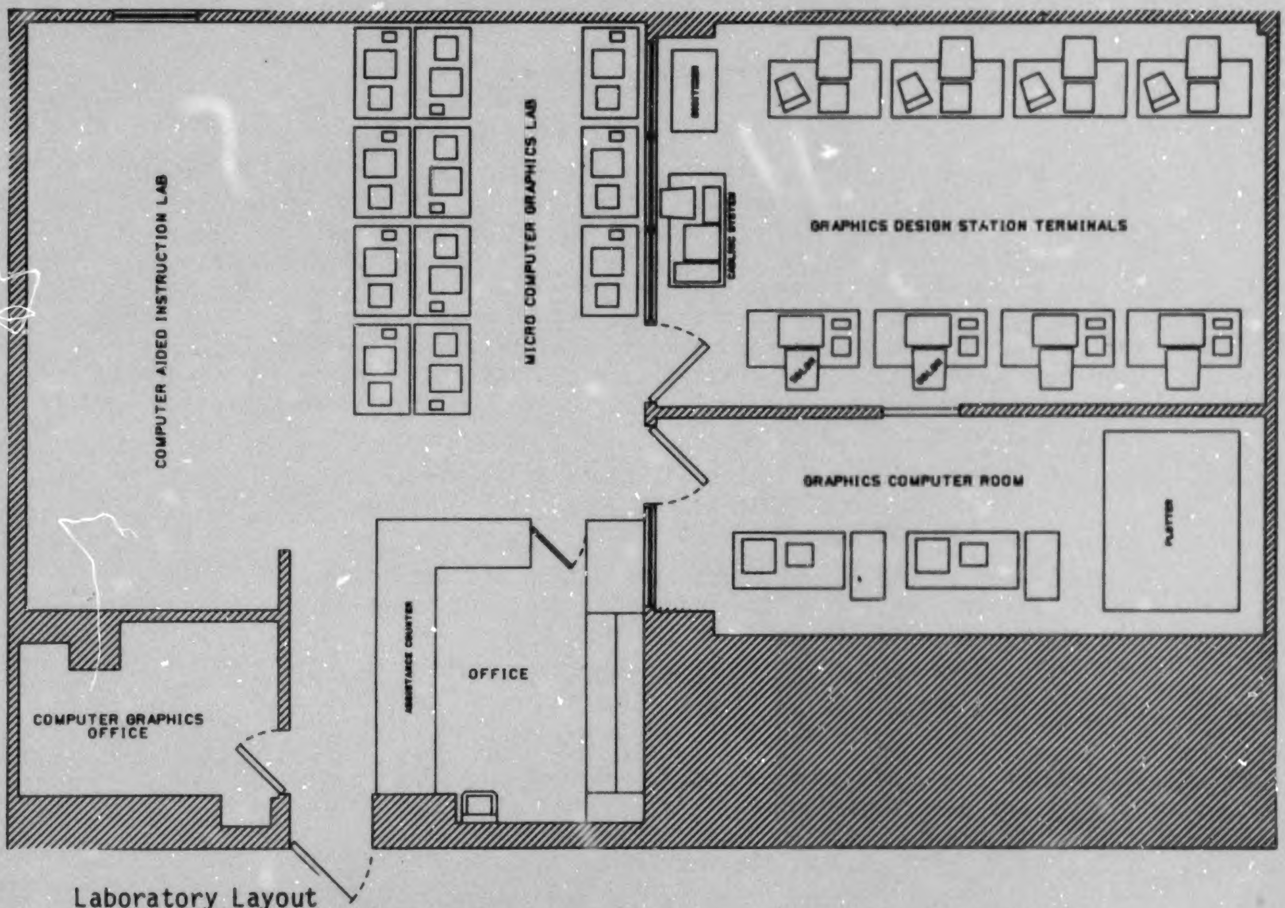
(1) System Control

* Emulation of Computervision's CADDS-3 command language syntax including mode prompts and response to syntax errors.
* Graphics tablet menu with 154 user-programmable function key squares.
* Split display screen with four lines of command text on the bottom and graphics on top, or full-screen graphics or full-screen text.
* Storage and retrieval of user-created drawings on flexible disk.
* Plotting of final drawings on a Hewlett-Packard 7470A plotter, or screen image dot matrix plotting on an EPSON MX-100 printer.
* Emulation of Computervision's log-in and log-out procedures.

(2) Geometry Creation and Modification

- * Complete data location specification capability through 20D Cartesian or polar coordinates, both absolute and relative (incremental).
- * Entity positioning capability for locating the ends or origin of existing entities.
- * Verification of entities and measurement of length, distance, and angles.
- * Emulation of entire Computervision insert line package (length, angle, parallel, perpendicular, horizontal, vertical, tangent to).
- * Complete circle insertion procedure (three-point, two-point diameter, two-point radius, explicit radius, or diameter).
- * Six ways of inserting arcs, including specification of beginning and ending angles.
- * Inserting points.
- * Inserting fillets by radius with automatic trimming.
- * Trimming circles, arcs, and lines.
- * Inserting text.
- * Dimensioning package with specification of text positioning, precision, extension line suppression, and arrows in and out.
- * Full 256 layering capability.
- * Translation, rotation, or mirroring of existing entities with a copying option.
- * Erasure of entities by entity type.
- * ZOOM ALL, ZOOM EXTENT, ZOOM UP AND DOWN, ZOOM WINDOW.
- * PAGE DISPLAY, SAVE DISPLAY, RESTORE DISPLAY.
- * Full selection, specification, and activation of grids.

MATC MICRO-CAD Emulates
Computervision's CADDS Software


COMPUTER AIDED INSTRUCTION LAB
MICRO COMPUTER GRAPHICS LAB
CABLING SYSTEM
GRAPHICS DESIGN STATION TERMINALS
GRAPHICS COMPUTER ROOM
PLOTTER
ASSISTANCE COUNTER
OFFICE
COMPUTER GRAPHICS OFFICE

Laboratory Layout

The computer graphics facility was merged with a timesharing computer terimal laboratory which is available to students and faculty for technical computation, computer assisted instruction, and computer literacy. The open lab concept with multicourse service to all instructional departments was the basis for the design. Originally a classroom with a demonstration terminal was needed, but as faculty became experienced in teaching, the terminal in the classroom was used less and less. The classroom portion has now been converted to a laboratory for the Computervision design stations, as shown here.

Maintenance of Equipment

When a timesharing system goes down and there is no backup, it is critical to have immediate maintenance. The equipment vendor provides a monthly rate for services which has provided about 98% reliability in system operation. The microcomputers are maintained by the college Audiovisual Department.

CAD Systems Covered

Students who learn to create complex design geometry on one system are able to transfer skills to another system. The operator can refer to the system manual or call up the command library displayed on the screen. The actual system the student learns is not as important as the CAD geometric applications, concepts, and principles (follow-up study of 116 students).

CAD Employment Outlook

Types of Jobs Available

The area with greatest incidence of application is in the CAD fields of mechanical design, electrical design, and mapping, with applications growing in structural design, architecture, commercial art, and computer aided manufacturing (CAM). The growth of computerization and automation in areas of information management, engineering, and manufacturing is compounding at over 30% a year through the 80's (Anderson Report, December, 1981). Job opportunities for persons with skills in computer graphics are growing equally fast. The general area of jobs and level of training are categorized as follows: (excluding specialization such as mechanical, electrical, etc.)

a) Operate CAD design station, basic digitizing, inserting parts - high school grad with drafting and CAD operator training.

b) Operate CAD design station, drafting and designing tasks - vocational training with drafting, some design, and CAD operator training.

c) Operate CAD design station, drafting, design, and some analysis - two years of college with CAD operator training, drafting, and some analysis.

d) Engineering, perform analytical tasks for design and direct design staff for routine analysis problems or for specialized analytical routines - B.S. with engineering and CAD operator training.

e) Other jobs in areas of Computer Aided Manufacturing (CAM) (numerical control or robotics programming and operation, quality control, etc.), technical illustration, television animation, and printing can use computer graphics at various levels of employment.

Job Outlook Nationally

Today 45 to 55% of the workforce is estimated to be in the information business. By the year 2000, the figure is expected to rise to 80%. Three out of four jobs in the 1980's will require technical training below the baccalaureate level, according to the Bureau of Labor Statistics as reported in "The Shortage of Skilled Workers" position paper, American Vocational Association. In the January, 1982, Electronic Design, "1982 Technology Forecast," it was reported that 7,500 CAD workstations had been installed by the end of 1979, and the number is forecast to grow to 75,000 by the end of 1985. A conservative view leads to the estimate that 50,000 CAD systems will be installed in these four years: 1982, 1983, 1984, 1985. Assuming that 20% of the existing CAD operators leave the field each year and each CAD station is used 1.5 shifts, there is a need to train some 100,000 operators in the four years ahead. In addition, there are many more engineering students, business persons, and engineers who must also be oriented in CAD.

Local or Regional Job Needs Survey

The number of computer graphics systems installed in the Milwaukee area was first surveyed in 1977 by telephoning over 90 industries, and 23 users were found. By 1981, a survey completed by the Wisconsin Chapter of the NCGA found 49 systems and in 1982 this had grown to 88 systems. With an estimated 4 CAD operators per system and 1.5 shifts there should be 528 jobs, and with a 20% turnover plus a 30% growth per year a need for 263 trained persons is projected for 1983. This does not include students, business persons, engineers, computer aided manufacturing persons, and graphic arts or television personnel, as well as other users. The need (possibly demand) was fully realized in the fall of 1982 with over 500 persons on a waiting list for a beginning computer graphics course.

CAD Curriculum Development

Pioneering curriculum development was initiated by General Electric Medical Systems in 1978 to help alleviate a shortage of computer graphics workers. GE reported there was extreme competition between employers for trained personnel, which resulted in a high overhead cost to cover on-the-job training and out-of town recruitment of employees. The cost of training one person up to a level of 1 to 1 productivity was reported as $10,000 each by General Dynamics of San Diego and Martin Marietta of Denver (1980 NCGA Conference Proceedings).

Needs Assessment

A faculty ad hoc committee drawn from representative application fields recommended curricular areas in need of computer graphics training and possible hardware/software, and suggested seeking the advice of an industrial advisory committee. A study visit to the BYU CAD program established in 1976, a survey of local users, and the advisory committee confirmed the need for integration of CAD into eleven program areas. In 1979 MATC staff assisted GE with improvements of its CAD training program and received reciprocal assistance in developing a curriculum, selecting a CAD system, and obtaining vendor contributions.

Advisory Committee

The project advisory committee is usually made up of two members from each occupational area; (mechanical, electrical, civil, architectural, graphic arts, CAM), a high school representative, university representatives, and project faculty. The committee meets two or three times per year and reviews progress of faculty curriculum development, course evaluation, logistical data, and subcommittee recommendations. The subcommittee concentrates on specific occupational areas and has expanded membership to include additional state-of-the-art users in key industries. The project committee's development and curriculum recommendations are referred to the traditional occupational program advisory committee. The program advisory committees are responsible for making recommendations for program development, beginning at the local level of instruction all the way through to the state program-approval procedure. In many cases, the membership serves on both committees.

CAD Integration into MATC Programs

The emphasis at MATC has been, first, to develop basic engineering skills, and second, to provide computer skills that can solve typical engineering/design problems. Knowing how to use a slide rule will speed up engineering if you know engineering. Learning how to use CAD as a tool should similarly speed up production. The challenge has been to determine exactly how computer graphics skills can be integrated into an existing curriculum. Each course and course objectives must be analyzed to integrate these new concepts and experiences into a two-year program. The first priority was the Mechanical Design Technician program, where computer graphics objectives have been integrated into at least six courses. In addition, two computer graphics courses have been developed--an introductory course, which provides computer graphics operation skills, and an advanced course to help students make applications to mechanical design problems, including three-dimensional and descriptive geometry. The generic introductory CAD course is also open to students in Electrical Technology, Civil Engineering Technology, Numerical Control, Commercial Art, Printing and Publishing, and Architectural Technology programs. An advanced course in electrical design includes printed circuit boards, electrical schematics and other related applications. A new Electrical Design Technology program now being developed will emphasize the basics of mechanical design, electrical theory, and electrical drafting first; then add computer graphics skills and electrical CAD. Civil Engineering, Architectural Technology, and Commercial Art Departments are developing advanced application courses that are primarily offered as continuing education opportunities or as assignments for regular full-time students. Continuing education courses offer an opportunity to test new areas with an industrial group, obtain direction for associate degree programs, and establish a relationship with a community of users. In a departure from engineering applications, computer graphics is being integrated into the Telecasting program at MATC's Channels 10 and 36. MATC's training opportunities in computer graphics are also being developed in production-related occupations where design data bases become accessible for production purposes. The Welding Technology Department is developing instructions for obtaining maximum number of parts cut out of a metal plate, automated flame cutting, and robotic welding. The Numerical Control Department developed a CAD to CAM interface going from design to actual cutting operations on numerically controlled machine tools. The Electrical Technology Department teaches industrial controls and other automation devices in a move toward computer-integrated manufacturing. The Electromechanical Technology program is emerging as the basic program for preparing robotic service technicians. The Industrial Engineering program brings together all CAD/CAM activities for efficient management of manufacturing and industrial processes.

Curriculum Outline

The 11 programs needing integrated CAD skills have been identified as having skills provided in existing courses, in elective CAD courses, and required CAD courses. The development of the Mechanical Design Technician and Electrical Design Technology programs (which have the highest priority) is evolving with CAD courses. The programs shown here are in recommended sequence. These program outlines are tentative, subject to advisory subcommittee and committee action, and may be substantially changed before acceptance. The purpose of showing the tentative programs is to provide future direction based on over two years of development rather than showing minimal requirements early in the development phase. Current official programs show only elective treatment of CAD skills.

Proposed Revised Mechanical Design Technician Program

First Year - Semester One

Technical Drafting 1 -- 3 credits
Mechanical Design Technician Orientation -- 0 credit
Manufacturing Processes 1 -- 3 credits
Communication Skills 1 -- 3 credits
Technical Mathematics 1 -- 4 credits
Physical Education - 1 credit
Psychology of Human Relations -- 3 credits

Semester Two

Technical Drafting 2 -- 3 credits
Manufacturing Processes 2 -- 3 credits
Communication Skills 2 -- 3 credits
Technical Mathematics 2 -- 4 credits
Technical Physics 1 -- 4 credits
Introduction to Interactive Computer Graphics -- 2 credits

Second Year Semester One

Technical Drafting 3 -- 3 credits
Descriptive Geometry -- 3 credits
Statics and Strength of Materials -- 4 credits
American Institutions -- 3 credits
CADDS 1 -- 2 credits
Elective -- 2 credits

Semester Two

Basic Tool Design -- 3 credits
Design of Machine Elements -- 3 credits
Basic Mechanisms -- 4 credits
CADDS 2 -- 2 credits
Design Problems -- 2 credits
Business and Industrial Relations -- 3 credits
Elective -- 2 credits

NOTE: The first CAD course is a generic two-dimension course offered in second semester, the second CAD course is a generic three-dimension course offered in third semester, and the third CAD course specializes in mechanical applications offered in the fourth semester. The courses CADDS 1 and CADDS 2 have been proposed and would replace the existing three-credit "Computer Graphics Mechanical Design Applications" course which is presently an elective.

Proposed New Program in Electrical Design Technology

First Year:

Same as Mechanical Design Technician Program

Second Year - Semester One

Technical Drafting 3 -- 3 credits
Descriptive Geometry -- 3 credits
DC and AC Fundamentals -- 4 credits
Electrical Drafting -- 3 credits
Electronics Manufacturing Processes -- 3 credits

Semester Two

Electrical Applications of Computer Graphics -- 3 credits
Electrical Design Problem -- 2 credits
American Institutions -- 3 credits
Business and Industrial Relations -- 3 credits
Electives -- 6 credits

Possible Electives

Strength of Materials -- 3 credits
Basic Tool Design -- 3 credits
Design of Machine Elements -- 3 credits
Basic Mechanisms -- 3 credits
Electronic Circuits -- 4 credits
Electronic Fabrication -- 2 credits
Instrumentation Circuit Design -- 3 credits

Course Development

The first course offered at MATC on an industrial computer graphics system began in August 1980 with two Computervision design stations and 69 students. It was the first known industrial-type interactive computer graphics course offered on-campus at a two-year technical college in the U.S.

The initial curriculum designed for the course was developed in conjunction with a need for CAD training at GE. Max Raisor of the BYU CAD program assisted MATC as a consultant with curriculum and methodology decisions. MATC sent John Erbes, Computer Graphics Coordinator, to the vendor (Computervision) CAD operator training course, and also acquired materials from various corporate in-house training programs. The course materials from General Dynamics of San Diego were most helpful, and the advisory committee provided guidance in stating original objectives. The teaching faculty met frequently to review assignments, exercises, and tests. After 2 1/2 years of development, general agreement has finally been reached on the design parameters of the generic introductory 2-D computer graphics course. For the most part, advanced courses have been one-department responsibilities, and advisory subcommittees have been involved to guide development.

A few of the people taking the introductory course in computer graphics have the mistaken idea that this one course will open up their employment opportunities. Completing an introductory course in computer graphics does not guarantee employment in fields such as computer-aided drafting or computer-aided design. Such opportunities exist only after one has acquired other supportive technical training and skills in specialty areas such as mechanical, electrical, architectural, or structural design; mapping; television; commercial art; printing; engineering; or manufacturing. Complete preparation for a career requires either a comprehensive technical background or additional technical courses.

Basic Course Competencies Developed

The basic CAD course, "Introduction to Interactive Computer Graphics" (2 credits), includes description of computer graphics systems, advantages, applications, and operational skills with emphasis on construction geometry and developing a data base. Competencies include 1) inputting geometric data via keyboard, digitizer, and menu with stylus; 2) editing, filing, retrieving, and screen controls such as zooming, mirroring, rotating, and layering; 3) outputting data for plotting and printing. The operational skills are applied to a 2-D design problems including dimensioning and text. The first course was designed as a generic course with some specialization occurring in the final project.

Prerequisites

The purpose of this course is to allow you to apply your existing technical skills to a new technology. The background skills for this course require one semester of drafting or a year of experience. It is also helpful to have some math background such as algebra or geometry to understand coordinate geometry. A background in computers or computer programming is not necessary

Course Objectives

At the conclusion of this course the student will be able to:

1. Identify the components of a computer graphics system.
2. Apply geometric principles in creating 2-D drawings on a computer graphics system.
3. Create 2-D drawings using the graphics terminal, digitizer, and plotter as design and drafting tools.
4. Apply conventional industrial practices in creating and storing drawings as a common data base for documentation, manufacturing, accounting, etc.

Units of Instruction

1. General Description of Computer Graphics
2. Computer Graphics System Operation
3. Basic Entity Creation
4. Using Screen Control Commands
5. Grids and Coordinate System Review

MATC Wells Index Computer Numerical Control (CNC) Milling Machine

6. Inserting Lines, Circles, Arcs, Points
7. Inserting Dimensions and Text on Drawings
8. Changing Text
9. Entity Modification
10. Grouping, Tagging, and Chaining
11. Crosshatching and Line Fonts
12. Mirroring, Moving, and Rotating with Copy
13. Layering
14. Operation of Equipment

Advanced Computer Graphics Training

MATC offers opportunities to apply advanced computer graphics system to further automate design, engineering, and manufacturing processes. The student entering advanced courses needs even more technical skills in his/her specialty areas. The person with both the technical skills and advanced computer graphics training has numerous employment opportunities available. Currently there are three advanced courses offered, one in Mechanical Design, one in Electrical Design, and one in Computer Aided Manufacturing. There are several others in development. Future advanced courses are planned, including structural design, architecture, technical illustration, robotic modeling, and numerical control machining.

Advanced CAD Course Competencies Developed

"Computer Graphics Mechanical Design Applications" (3 credits). Instruction emphasizes skill development in three-dimensional mechanical design applications using interactive computer graphics. Topics covered include 3-D construction techniques, auxiliary views, view ports, conic sections, surface construction, intersection, sectioning, multi-view and assembly drawings, bills of materials, and mass properties computations. Prerequisites: "Introduction to Interactive Computer Graphics" and "Descriptive Geometry."

Numeridex and Cadlinc systems processing Computervision's data and directly interfacing CNC milling machine.

Units covered include:

1. Entry Options
2. Dimensioning
3. Tolerancing
4. Constructing 3-D Parts
5. Ports
6. Inserting Entities in Isometric View
7. Editing and Dimensioning Isometric View
8. Descriptive Geometry
9. Defining and Creating a Plane
10. Defining and Creating a Surface
11. Creating a Mesh
12. Creating Multipart Drawings
13. Automatic Hidden Line Removal
14. Mass Properties
15. Perspective View

"Computer Graphics Electrical Design Applications" (3 credits). This course applies an interactive computer graphics sytem to create, store, and document electrical design information. The design of schematics, wiring diagrams, ladder diagrams, multilayer printed circuit boards, panel layouts, and wiring harnesses is included. Lectures on computer assisted design are provided, and extensive hands-on activity with an interactive computer graphics system is emphasized. Prerequisites: One year of practical drafting experience and one course in introductory computer graphics, or consent of instructor. Experience or training in basic electrical theory is also desirable. Units covered include:

1. Review of Basic Fundamentals of Computer Graphics, Course Overview
2. Layering Concepts
3. Nodal Entities
4. Using Nodal Entities

5. Nongraphic Properties
6. Making Schematics and Ladder Diagrams
7. Inserting Nodal Text
8. Library Figures for PC Board Design
9. Circuit Board Layout
10. Text Files
11. Routing the Board
12. Edit Board
13. Preparation of Documentation
14. Application of Documentation
15. Other Electrical Applications

Advanced CAD/CAM Course Developed

The Computervision CAD system at MATC is interfaced through a processor to a CNC milling machine (Wells Index). The processor is either a Numeridex or Cadlinc for file management of NC data.

"CAM/NC Programming" (3 credits). Instruction is given in the construction of a tool path from a previously defined data base. Instruction will also include creating a cutter location file which will be used in part processing. Prerequisite: "Introduction to Interactive Computer Graphics" or consent of instructor. Units covered include:

1. Introduction
2. Editor
3. Basic Construction - Menu, Log-In, Log-Out
4. Tool Library
5. Machine Point to Point (MPTP)
6. Machine
7. Post Processing - 1 and 2
8. Append, Regenerate, Verify - Use, Save, MPTP
9. Machine Profile (MPRO)
10. MPRO - Append, Regenerate, Verify - Use, Save MPRO
11. Machine Pockets (MPOC)
12. MPOC - Append, Regenerate, Verify - Use, Save MPOC
13. Sets, Supersets, Linking and Unlinking
14. Edit Numerical Control Operations
15. Machine Absolute
16. Machine Absolute - Lathe

Integrated Course Competencies Developed

Students in programs not having an elective or required course option receive introduction training by class lectures, visits to computer graphics center, and assignments. Students in advanced courses who have received introductory training have an opportunity to apply CAD as an option to manual procedures. Specific examples in the Mechanical Design Technical Program (606) include:

606-106	Technical Drafting 3 - Computer graphics used in tolerance stackups.
606-130	Statics and Strength of Materials - Computer graphics used in center of gravity, areas, volumes, moments of Intertia, etc.
606-112	Basic Tool Design - Computer graphics used in the design of fixtures and gages.
606-118	Basic Mechanism - Computer graphics used in determining displacements, velocities, and accelerations pertaining to mechanisms.

Continuing Education Minicourses

Special one-day or two-day courses are offered to employees from industry to introduce CAD skills to manual drafters, designers, and manufacturing persons. The first day is a generic 2-D CAD mini course offered as a prerequisite to second-day applications or a 3-D mini course. Some minicourses are aimed at experienced users, providing a technical update.

Teaching Techniques and Structure

The courses have a basic curriculum with the teacher having the complete responsibility for instruction and evaluation. The course materials are competency based and implemented with a lecture/lab teaching strategy to retain the flexibility needed in a changing technology. With the high cost of high-technology training stations, it was not possible nor desirable to schedule a group lab for students with only two design stations. Obviously an open lab with technical expertise available was the only way possible to achieve cost-effective utilization.

CAD course structure includes 2 or 3 credits for 15 to 18 weeks or, offered in a summer session, for 2 or 6 weeks. The activities include:

Lecture

One hour per week or two hours per week for 3-credit courses are scheduled in a classroom setting, using overhead slides and other audiovisual media. Originally, teachers needed a design station in the classroom for lecture, but after they gained more experience and a student manual was developed, classes were conducted without the design station.

Demonstration Lab/Quiz Section

One hour per week is scheduled in the classroom and/or lab when the teachers can demonstrate operations, answer questions, go through practice exercises which were assigned to rehearse system operation, and administer and review for quizzes. This session provides students the opportunity to obtain teacher assistance not available in an open lab.

Open Lab

Two hours per week or up to four hours for three credits. The students reserve a design station to complete assigned lab exercises sometime during the 70 hours per week of open lab. Students sign up for a station in twos or threes. Single students can be bumped by any group of students in order to encourage group sign-up. The group is instructed to shift responsibilities of operator and resource person. It has been found that a pair of students working together is more effective than singles or threes. The open lab is staffed with a person familiar with operation of equipment and lab exercises. Also, a systems manager is available to solve hardware and software problems.

Home Study

Two hours per week of reading, practice exercises to rehearse system operation, and studying.

Learning Activities

The student learning activities in the first course are directed by a course manual divided into instructional units. Each unit begins with a rationale statement or purpose, objectives, reference section, assignment section, and lab exercises. The student entering a course needs immediate hands-on which is accomplished by providing an exercise with each operation step described. As the commands and procedures are learned, the exercises become less directive. Also, the commands begin in the most elementary form for each geometric entity and are continuously reinforced and expanded upon throughout the course. For example, you start with basic points, lines, circles, arcs, etc., and evolve to different ways of constructing the entities. Many variations are applied with the vast capabilities of a CAD system to continuously build skill levels. Emphasis is on problem solving and generic construction concepts permitting an easy transfer to different CAD systems.

Competency Evaluation Tests

The students are assigned lab exercises which must be completed for each instructional unit. Several quizzes are given, graded, and discussed in demonstration, lab/quiz section. A midterm exam and final exam are major tests for grading. Quizzes and tests have been paper and pencil rather than actual system operation. Some teachers also check off the assigned home study exercises, which has proved to encourage student participation.

Credit Value

The credit value of courses was extensively debated, and after a study of lab time and home study time it was concluded that the two-credit value was more suited to the introductory course. There is a tendency to inflate credits in high-tech courses when the instructor desires to include more specialized applications. With an adequate text and course objectives restricted to a generic course, two credits were reasonable. The specialized applications beyond the final project must occur in advanced courses or in other technical courses.

Faculty Development

The development of a high technology area can be a goal of an organization but it is unlikely the results will be successful unless qualified and motivated individuals are involved. In many colleges you will find highly successful programs emerging without significant support given, and it is due to extreme motivation of individuals in spite of the many barriers.

Faculty members are expected to be leaders in their field and secondly, to have tremendous motivation to acquire new techniques. The leader who provides basic CAD operator training to students can get by with minimal operator level background. Teachers who are to provide advanced level training to employees operating a CAD station eight hours a day are a staffing problem, however. The teacher must either be a part-time faculty member from industry with expertise or the regular full-time staff must be given considerable development time over a period of one or two years. During development, the teacher must become an expert user of the CAD system, must have developed a library of specialized application programs, and must have spent considerable time with various industrial users.

Initial Faculty Appointments

Teachers were selected from existing full-time staff as recommended by the instructional division in priority areas, generally without a computer graphics background. In the beginning, four faculty members and project staff were needed to learn the new system together, create files, and develop teaching materials. A graduate of BYU who worked as a local system manager became a part-time faculty member, and teamed with a full-time teacher and MATC Computer Graphics Coordinator to offer the first course within eight weeks of system installation. In August of 1980, 69 students started in a two-design station lab.

Additional Faculty Appointments

During the first year full-time MATC faculty were attracted to becoming a part of the development team with an offer of summer employment, learning a new technology, and professional development assignment with a reduced teaching load. Any interested teacher was invited to apply by submitting a letter of application endorsed by the departmental supervisor. The teacher was invited for a screening and interview including a review of previously developed teaching materials. The interview was conducted by a team of three: Project Director, Computer Graphics Coordinator, and Department Supervisor. The appointed teachers were in the occupational areas given highest priority by the advisory committee, had completed the beginning computer graphics course, and were placed in the highest overall rating category by the interview team according to defined criteria.

Screening Interview Criteria for NSF Project Faculty

(1) Review letter of application: Computer graphics and computer experience, (specialty area) experience, recent practical experience, and curriculum development experience.

(2) Review sample instructional materials. Previously developed units, syllabus, course outlines, etc.

(3) How do you feel Computervision system can be utilized in your field?

(4) Names of (specialty area) computer graphics user companies, application, name of individuals with computer graphic specialty area experience who could serve on advisory subcommittee.

(5) Where does computer graphics fit into specialty area related program? Courses? Student exercises? How much lab time? How would you modify these related programs?

(6) What workshops or courses are needed for continuing education?

(7) What do you think you should do in the summer if you are on the project? Highest priorities?

(8) Would you be willing to teach computer graphics related courses or workshops in day school, evening school, or Saturdays for associate degree, adult vocational, high school contract, and apprentices?

(9) Would you be willing to write or prepare all documentation needed for instructional units, syllabuses, course, programs, project reports, etc.?

(10) Why do you think you should be given this assignment?

Faculty Training in CAD

The selection process does not include assigning a teacher to training; it is strictly an option or choice of the teacher. Since it is a requirement to get on the project, many teachers are motivated to register for the regular MATC course and complete the course like any other student. A plan for special in-service was dropped in view of the apparent success of the strategy. The grades of faculty members registered in the course have usually been at the top of the class. In one summer two-week course with 12 teachers from several Wisconsin districts, the faculty were unanimously in favor of following the regular student course, including all assignments and tests, as preparation to integrate CAD into curriculum. A three-hour discussion on curriculum and methods proved to be a valuable post-course activity.

Faculty Development Plan

After the faculty member has been appointed, a plan for development is agreed upon by computer graphics staff and departmental supervisors. The plan usually requires (1) Teaching the beginning computer graphics course and then special application minicourses which further develops competencies in use of a CAD system and preparation of class materials. (2) Developing CAD application library that can be used in minicourses, advanced courses, or for assignments in other technical courses. (3) Establishing a subcommittee of industrial users to work with during curriculum development and preparation of course materials. (4) Developing stated goals in terms of plans for subcommittee meetings, courses to be taught, tentative schedules, reports for project and advisory committee meetings. Faculty members receive a partial professional assignment to develop these advanced skills. Other faculty members without this time must be extremely motivated individuals in order to achieve the CAD skills needed to be a leader in the field. The rapidly changing technology and needed work with industry take so much time that full-time teachers cannot keep up unless released time is provided.

Industry Resource Faculty

In the beginning most technical sources are available in the community, and methods to utilize these persons must be established. When MATC started the study of CAD, a full-time faculty member, along with a coordinator on a part-time basis, was placed at a local industry on professional assignment. The purpose was to go through a company CAD training program, acquiring skills while serving as training consultants to help the industrial trainers in improving teaching techniques and organizing courses and materials. After this one-semester assignment, the basic curriculum was developed, and a continuing relationship helped guide development of the facility and selection of a CAD system. As the CAD system was acquired and the first courses scheduled, the faculty needed assistance from experienced industrial persons. A part-time faculty member, who was a graduate of the BYU CAD four-year program and a local CAD manager, taught one section of the beginning class. Meetings were held weekly with regular full-time faculty to develop lectures, lab exercises, and tests. In subsequent semesters more sections were added and more industrial adjunct faculty added. Meetings between full-time and part-time faculty continued until the curriculum and teaching materials were perfected. During the academic year, guest lecturers conducted special student programs in specialized topics related to CAD, and a number of field trips were scheduled.

Conclusion

The project implemented a high cost industrial CAD/CAM technology achieving a ratio of 35 students to 1 design station per semester in open lab available 80 hours per week. The design stations are valued at approximately $100,000 each with supportive hardware and software, which if depreciated over five years comes to approximately $5.00 per design station hour plus $1.25 per hour of pro rata maintenance costs. If less than 100% utilization, such as downtime during holidays, exams, early semester, etc., the total cost of industrial turnkey is approximately

$10.00 per hour, plus the cost of facility and staff. A donated system and/or microcomputer will substantially reduce these costs. It was obvious MATC needed to develop a low cost microcomputer CAD emulation to free the indutrial system of beginning students for use by the advanced users.

Data regarding course registration, completions, test results, grades, lab time, home study time, student course evaluations, and follow-up studies have been analyzed with the following conclusions:

1. 67% completion of those registered.
2. 70% students registered are industry employees upgrading skills.
3. Two credit courses and three credit course lab time, study time, and student opinion indicates credits are about right.
4. Correlation between lab time and grade was not significant whereas correlation between home study time and grade was significant.
5. Time spent completing assignments which rehearse CAD station activities reduced time required to complete lab exercises.
6. Students working in pairs at a CAD station (one as resource person and other as operator with roles changing) learned more effectively than singles or triples.
7. Students completing course and starting on entry level job (22) reported the time to learn a new system was less than a day. Emphasis in geometric construction, use of reference manuals, and on-line documentation permitted easy transfer from Computervision to Applicon, Calma, Autotrol, Gerber, CADAM, etc.
8. The productivity of students completing the beginning course is 1 to 1 in comparing CAD to manual drafting. This one semester course produces results comparable to employees in industry with six months on-the-job training. Employees after one year typically achieve 2 to 1 productivity and continue to improve with experience.
9. Faculty training in CAD was conducted by integrating faculty into student courses and reported in a faculty followup as a desirable and effective procedure.

Colleges desiring to offer CAD user courses may begin by obtaining a microcomputer CAD system. The faculty member applying this CAD system will take one to two years to become proficient. The technology is changing so fast, by the time the current state of the art CAD is learned, a new, more capable low-cost CAD system will be available.

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Reprinted with permission of Victor Langer, Instructional Resources Coordinator, Milwaukee Area Technical College, Milwaukee, WI 53203.

PROGRAM: One Computer-Assisted Design (CAD) course in the Mechanical Engineering Technology Program
INSTITUTION: Columbus Technical Institute
550 East Spring Street
P.O. Box 1609
Columbus, Ohio 43215
(614) 227-2400
CONTACT PERSON: Jackie Marshall
DEGREE: Only one-quarter course is described here. It is part of the Associate of Applied Science Degree program.
COURSE BEGAN: 1983

History

In 1982, a proposal was written that was to substantiate the need for incorporating Computer Aided Design/Computer Aided Machining (CAD/CAM) into the Mechanical Engineering Technology curriculum. The course was initially designed as an elective course.The principles taught in this course would then be applied in other scheduled laboratory courses. The following steps were taken during the planning of the CAD/CAM supplement to the program.

1. Ascertain information that identifies learning institutions with CAD/CAM incorporated in the curriculum within the State of Ohio.
2. Make contact, via letter, with the institutions and schedule an on-sight visit.
3. Gather data during the institutional visit about the make of the system in use; the length of time the system has been functional; any change in student enrollment due to the system; institutions's justification for the system.
4. Gather evidence that identifies those in business/industry that utilize a CAD/CAM system in the State of Ohio.
5. Make contact with these places of business and schedule an on-sight visit.
6. Procure information that will specify the make of the CAD/CAM system in use; the period of time the system has been employed; the number of staff assigned to the system's operation.
7. Acquire estimates from business/industry of the demands for future personnel requirements trained in the system's operation.
8. Research and document the data ascertained that supports the impact of CAD/CAM on the manufacturing arena.
9. Present findings from the various sources in the form of a Technical Memorandum for Record, to the Mechanical Engineering Technology staff.
10. Propose incorporating/not incorporating CAD/CAM into the Mechanical Engineering curriculum.

Consequently, a course titled Computer Aided Drafting (CAD) was introduced into the Manufacturing Engineering Technology program.

Advisory Committee

The advisory committee consists of representatives from area manufacturing concerns. Companies represented include:

Barneby-Cheyney Company
Rockwell International
Jeffrey-Dresser
General Electric Company
Western Electric
General Motors Corporation
Buckeye Steel Castings
Columbus Auto Parts
Crane Plastics, Incorporated

The Course

The course is offered within the Mechanical Engineering Technology program. At this time it is an elective course in the Associate Degree program but will become a required course in the near future. The course is also part of the Architecture, Electrical Engineering and Civil Engineering programs. The Manufacturing Engineering Technology program teaches the students about the design and performance of machines and machine elements, manufacturing processes, designs of manufacturing tools and machine practices. As CAD and CAM become more prevalent in area industries, it has become necessary to also include CAD training in the program.

The course is primarily set up as a laboratory and the assignments are project-oriented. As the curriculum develops, it is anticipated that there will be a larger lecture component included in the course.

Currently, the course is offered during the day to full-time students (currently 11 students are registered for the course) and as an evening course for workers in engineering positions (currently 12 students are enrolled in the night course).

The syllabus for the course follows.

MANUFACTURING ENGINEERING TECHNOLOGY
COLUMBUS TECHNICAL INSTITUTE
SYLLABUS

COURSE TITLE: Computer Aided Drafting (CAD)

COURSE NUMBER: 4603

TEXT: None

COURSE DESCRIPTION: Computer Aided Drafting will introduce the student to the current means of generating geometric representations on computer.

COURSE OBJECTIVES: Computer Aided Drafting is designed to introduce the students to the fundamentals necessary to do drafting/designing on a CAD system.

COURSE PREREQUISITES: A student must have previous course credit in drafting, mathematics, and descriptive geometry or the equivalent to course numbers 4601, 111, 1112, and 4607 respectively.

COURSE EVALUATION: The student is required to complete 14 laboratory exercises by the due dates provided in the syllabus under the assignment catagory. There will be two given that will consist of a drafting project. The project will be unfamiliar for only one quiz. The student will also be expected to explain the steps necessary to complete a geometric figure on the CAD system. The student's final project will be 50% of the final grade.

ATTENDANCE: Attendance is necessary to successfully complete course work. Due to the shortage of available equipment laboratory hours are limited to six hours per week. This means that the time other than class time for lab work will not be flexible. Limited hours have been considered in the preparation of the work required.

GRADING SCALE: The grading scale will be that established by the Manufacturing Engineering Department. It is as follows:

Percentile Average	Letter Grade
94 - 100	A
86 - 93	B
75 - 85	C
70 - 74	D
0 - 69	E

ASSIGNMENTS:

WEEK #	ASSIGNMENT	DUE DATE
1	Introduction to CAD	Jan. 6
	(A) Sign On/Off Procedure	
	(B) Function Keys	
	(C) Menu Fundamentals	
	(D) Lab #1	
2	(A) Review Lab #1	Jan. 13
	(B) Lab #2	
	(C) Dimension Lab #1	
	(D) Dimension Lab #2	
3	(A) Review Dimension Menu	Jan. 19
	(B) Lab #3	
	(C) Lab #4	
	(D) Lab #5	
4	(A) Review Previous Labs	Jan. 27
	(B) Quiz #1	
	(C) Lab #6	
	(D) Lab #7	
	(E) Lab #8	
5	(A) Lab #9	Feb. 3
	(B) Lab #10	
	(C) Lab #11	
	(D) Lab #12	
6	Plotting Fundamentals	Feb. 10
	(A) Lab #13	
	(B) Quiz #2	
7	Layering Fundamentals	Feb. 17
	(A) Lab #14 Using the Module Menu	
8	Final Project Using All Applications	March 16

Equipment

The school has purchased a Hewlett Packard 1000 and is using CEADS-CADD software from Holguin and Associates, Inc. (P.O. Box 12990, El Paso, TX 79912 915/ 581-1171). Currently there are eight stations in the lab. In the future, more equipment will be added to the lab.

Some of the technical specifications provided by the software follow.

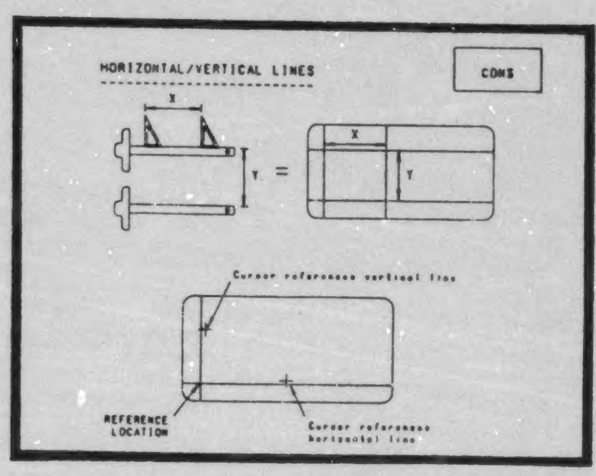
NOTE: Updates on the software have occured since these specifications were published. Please contact the vendor for current information.

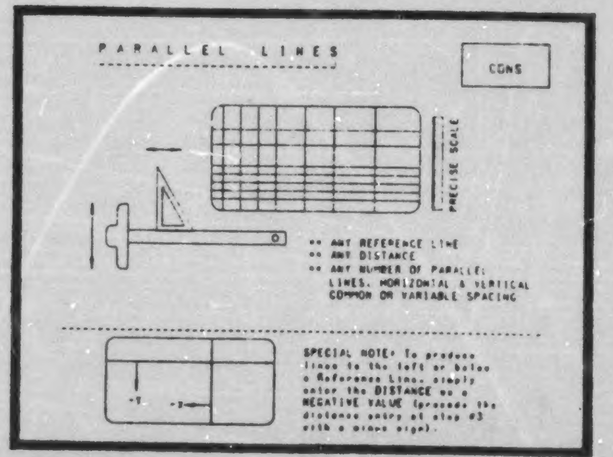
CEADS-CADD

Technical Specifications

HOLQUIN & ASSOCIATES, INC. P.O. Box 12990 El Paso, Texas 79912

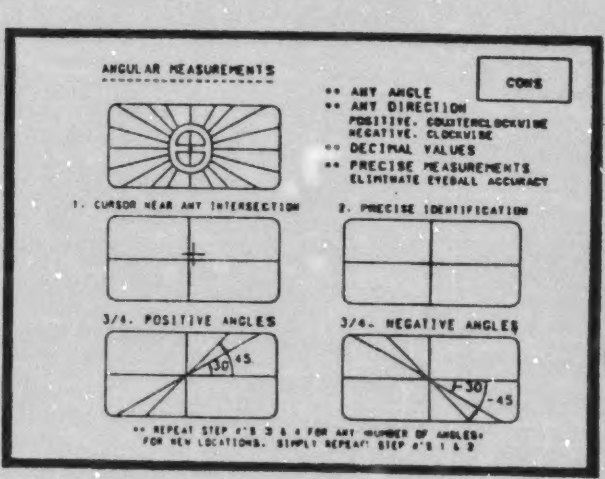
This graphics outline presents some of the design concepts established for CEADS-CADD. Contact your local CEADS-CADD representative for in-depth Technical Specifications and Certified Production Benchmarks


HORIZONTAL/VERTICAL LINES
CONS
X
Y =
X
Y
Cursor references vertical line
REFERENCE LOCATION
Cursor references horizontal line


PARALLEL LINES
CONS
PRECISE SCALE
-Y
-X

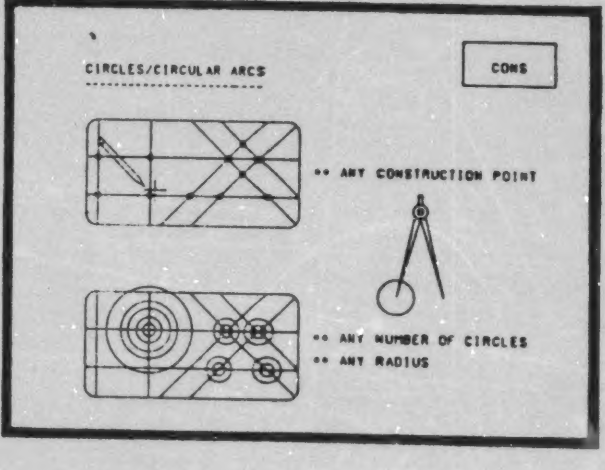
** ANY REFERENCE LINE
** ANY DISTANCE
** ANY NUMBER OF PARALLEL LINES, HORIZONTAL & VERTICAL COMMON OR VARIABLE SPACING

SPECIAL NOTE: To produce lines to the left or below a Reference Line, simply enter the DISTANCE as a NEGATIVE VALUE (precede the distance entry at step #3 with a minus sign).


ANGULAR MEASUREMENTS
CONS
1. CURSOR NEAR ANY INTERSECTION
2. PRECISE IDENTIFICATION
3/4. POSITIVE ANGLES
30
45
3/4. NEGATIVE ANGLES
-30
-45

** ANY ANGLE
** ANY DIRECTION
POSITIVE, COUNTERCLOCKWISE
NEGATIVE, CLOCKWISE
** DECIMAL VALUES
** PRECISE MEASUREMENTS
ELIMINATE EYEBALL ACCURACY

** REPEAT STEP #'S 3 & 4 FOR ANY NUMBER OF ANGLES; FOR NEW LOCATIONS, SIMPLY REPEAT STEP #'S 1 & 2

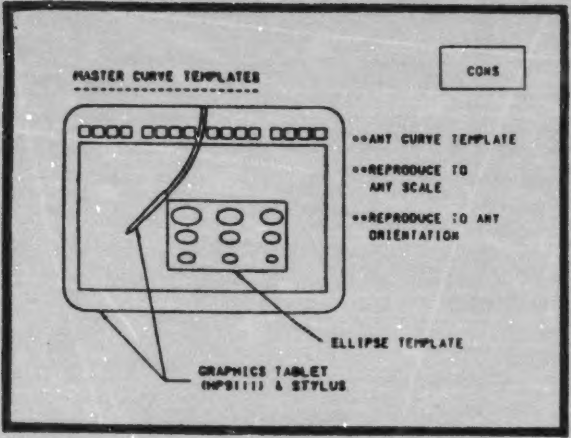

CIRCLES/CIRCULAR ARCS
CONS

** ANY CONSTRUCTION POINT
** ANY NUMBER OF CIRCLES
** ANY RADIUS

- **Construct**
- **Draw**
- **Dimension**
- **Edit**
- **Plot**

BEST COPY AVAILABLE

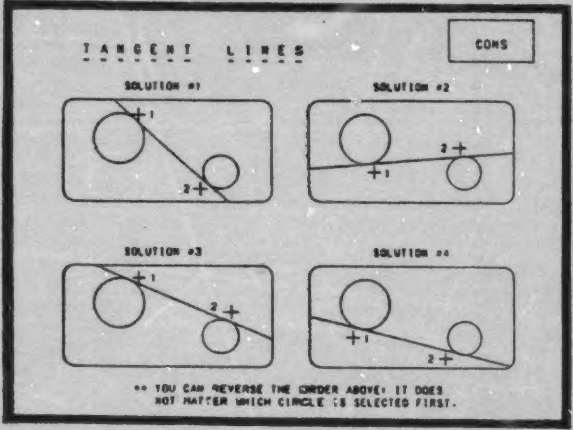
BEST COPY AVAILABLE


MASTER CURVE TEMPLATES

CONS

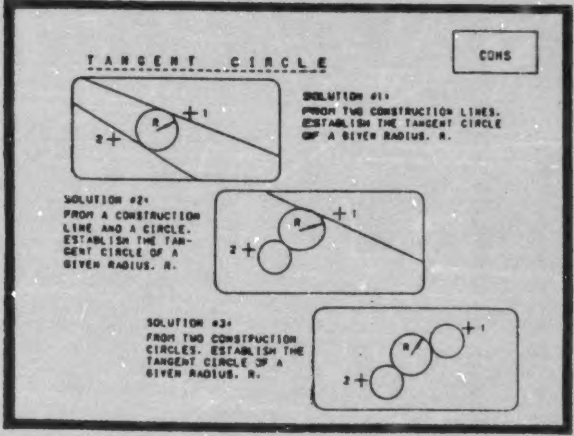
- ANY CURVE TEMPLATE
- REPRODUCE TO ANY SCALE
- REPRODUCE TO ANY ORIENTATION

- Automated Plotting System
- Digitizer Control System
- Mirror Image Extensions
- Area Fill/Area Calculations
- Archive/Tape Control System
- Disc Management System
- System Manager


TANGENT LINES

CONS

** YOU CAN REVERSE THE ORDER ABOVE: IT DOES NOT MATTER WHICH CIRCLE IS SELECTED FIRST.

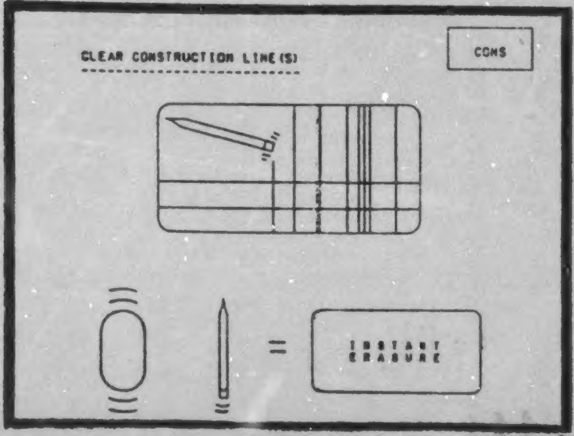

TANGENT CIRCLE

CONS

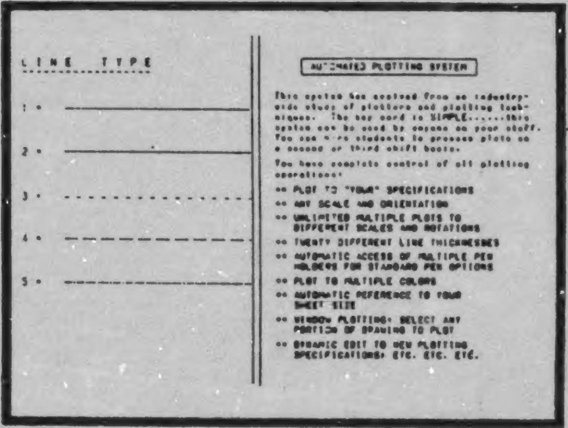
SOLUTION #1: FROM TWO CONSTRUCTION LINES. ESTABLISH THE TANGENT CIRCLE OF A GIVEN RADIUS. R.

SOLUTION #2: FROM A CONSTRUCTION LINE AND A CIRCLE. ESTABLISH THE TANGENT CIRCLE OF A GIVEN RADIUS. R.

SOLUTION #3: FROM TWO CONSTRUCTION CIRCLES. ESTABLISH THE TANGENT CIRCLE OF A GIVEN RADIUS. R.


CLEAR CONSTRUCTION LINE(S)

CONS

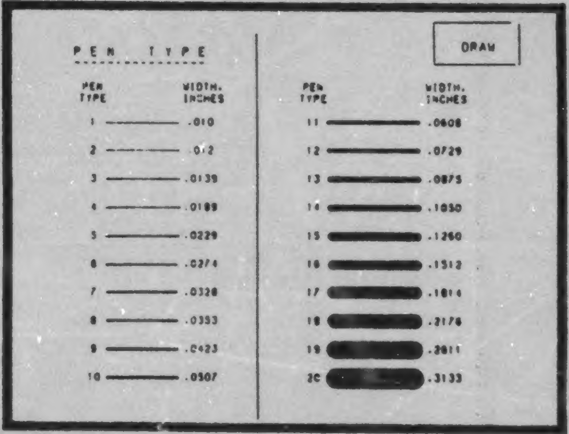

LINE TYPE

AUTOMATED PLOTTING SYSTEM

This system has evolved from an industry-wide study of plotters and plotting techniques. The key word is SIMPLE......this system can be used by anyone on your staff. You can hire students to process plots on a second or third shift basis.

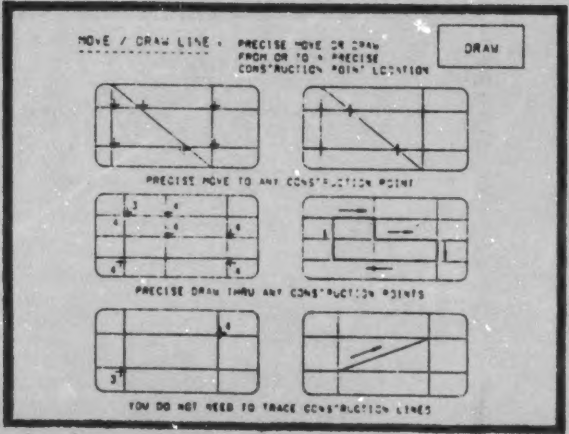
You have complete control of all plotting operations:

- ** PLOT TO "YOUR" SPECIFICATIONS
- ** ANY SCALE AND ORIENTATION
- ** UNLIMITED MULTIPLE PLOTS TO DIFFERENT SCALES AND ROTATIONS
- ** TWENTY DIFFERENT LINE THICKNESSES
- ** AUTOMATIC ACCESS OF MULTIPLE PEN HOLDERS FOR STANDARD PEN OPTIONS
- ** PLOT TO MULTIPLE COLORS
- ** AUTOMATIC REFERENCE TO YOUR SHEET SIZE
- ** WINDOW PLOTTING: SELECT ANY PORTION OF DRAWING TO PLOT
- ** DYNAMIC EDIT TO NEW PLOTTING SPECIFICATIONS: ETC. ETC. ETC.


PEN TYPE

DRAW

PEN TYPE	WIDTH, INCHES	PEN TYPE	WIDTH, INCHES
1	.010	11	.0608
2	.012	12	.0729
3	.0139	13	.0875
4	.0189	14	.1050
5	.0229	15	.1260
6	.0274	16	.1512
7	.0328	17	.1814
8	.0333	18	.2176
9	.0423	19	.2611
10	.0507	20	.3133


MOVE / DRAW LINE: PRECISE MOVE OR DRAW FROM OR TO A PRECISE CONSTRUCTION POINT LOCATION

DRAW

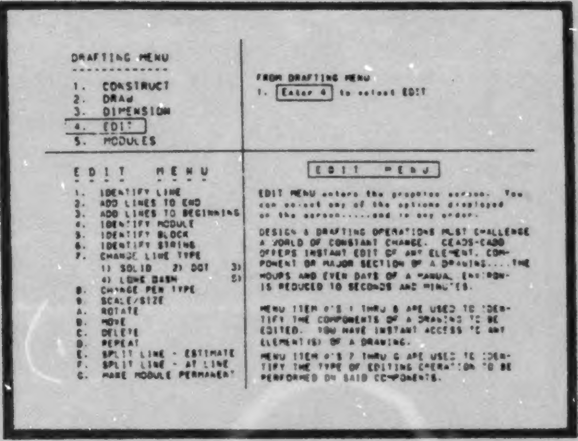
PRECISE MOVE TO ANY CONSTRUCTION POINT

PRECISE DRAW THRU ANY CONSTRUCTION POINTS

YOU DO NOT NEED TO TRACE CONSTRUCTION LINES

BEST COPY AVAILABLE

- **User-Selectable Parameters**
- **Master Construction System**
- **Drawing Dynamics**
- **Master Dimensioning System**
- **Edit Control System**
- **Master Module System**



DRAFTING MENU

1. CONSTRUCT
2. DRAW
3. DIMENSION
4. EDIT
5. MODULES

FROM DRAFTING MENU

1. Enter 4 to select EDIT

E D I T M E N U

1. IDENTIFY LINE
2. ADD LINES TO END
3. ADD LINES TO BEGINNING
4. IDENTIFY MODULE
5. IDENTIFY BLOCK
6. IDENTIFY STRING
7. CHANGE LINE TYPE
   1) SOLID 2) DOT 3)
   4) LONG DASH 5)
8. CHANGE PEN TYPE
9. SCALE/SIZE
A. ROTATE
B. MOVE
C. DELETE
D. REPEAT
E. SPLIT LINE - ESTIMATE
F. SPLIT LINE - AT LINE
G. MAKE MODULE PERMANENT

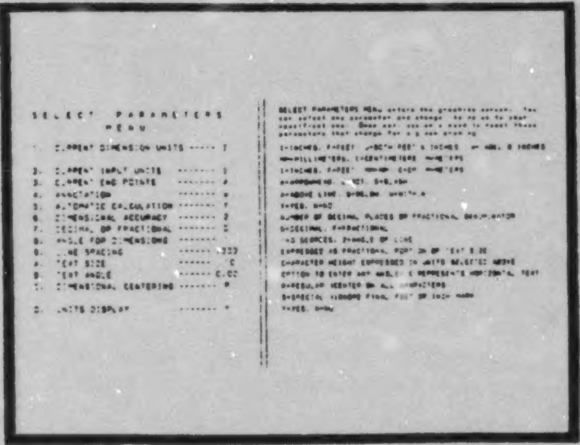
EDIT MENU

EDIT MENU enters the graphics screen. You can select any of the options displayed on the screen.....and in any order.

DESIGN & DRAFTING OPERATIONS MUST CHALLENGE A WORLD OF CONSTANT CHANGE. CEADS-CADD OFFERS INSTANT EDIT OF ANY ELEMENT, COMPONENT OR MAJOR SECTION OF A DRAWING....THE HOURS AND EVEN DAYS OF A MANUAL ENVIRON- IS REDUCED TO SECONDS AND MINUTES.

MENU ITEM #'S 1 THRU 6 ARE USED TO IDENTIFY THE COMPONENTS OF A DRAWING TO BE EDITED. YOU HAVE INSTANT ACCESS TO ANY ELEMENT(S) OF A DRAWING.

MENU ITEM #'S 7 THRU G ARE USED TO IDENTIFY THE TYPE OF EDITING OPERATION TO BE PERFORMED ON SAID COMPONENTS.



S E L E C T P A R A M E T E R S M E N U

1. CURRENT DIMENSION UNITS ------ I
2. CURRENT INPUT UNITS -------- [illegible]
3. CURRENT END POINTS -------- [illegible]
4. ANNOTATION -------- [illegible]
5. AUTOMATIC CALCULATION -------- Y
6. DIMENSIONAL ACCURACY -------- 2
7. DECIMAL OR FRACTIONAL -------- D
8. ANGLE FOR DIMENSIONS --------
9. LINE SPACING -------- [illegible]
A. TEXT SIZE -------- [illegible]
B. TEXT ANGLE -------- 0.00
C. DIMENSIONAL CENTERING -------- [illegible]
D. UNITS DISPLAY -------- [illegible]

SELECT PARAMETERS MENU enters the graphics screen. [illegible]

I=INCHES, F=FEET [illegible]

M=MILLIMETERS, C=CENTIMETERS [illegible]

I=INCHES, F=FEET [illegible]

[illegible]

[illegible]

NUMBER OF DECIMAL PLACES OR FRACTIONAL [illegible]

D=DECIMAL, F=FRACTIONAL

[illegible]

[illegible]

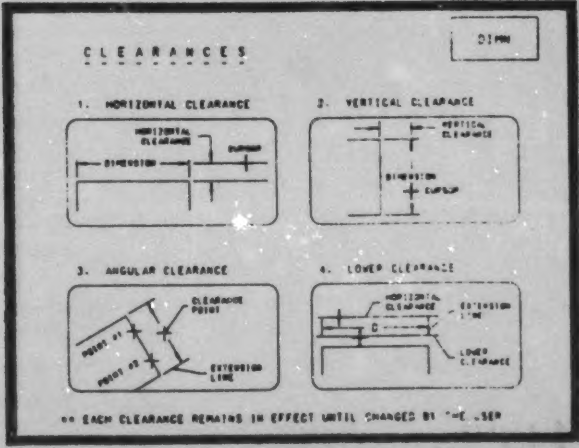
CHARACTER HEIGHT EXPRESSED IN UNITS SELECTED ABOVE

OPTION TO ENTER ANY ANGLE, 0 REPRESENTS HORIZONTAL TEXT

[illegible]

[illegible]

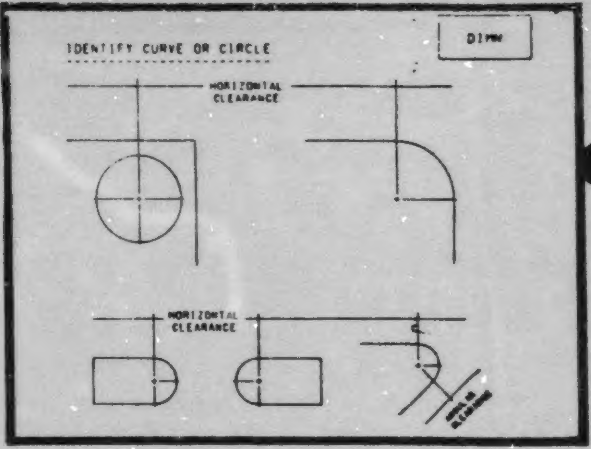
[illegible]



C L E A R A N C E S

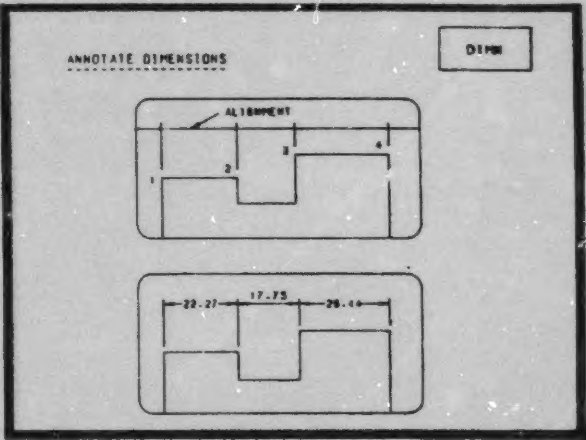
DIMN
1. HORIZONTAL CLEARANCE
HORIZONTAL CLEARANCE
CURSOR
DIMENSION
2. VERTICAL CLEARANCE
VERTICAL CLEARANCE
DIMENSION
CURSOR
3. ANGULAR CLEARANCE
CLEARANCE POINT
POINT #1
POINT #2
EXTENSION LINE
4. LOWER CLEARANCE
HORIZONTAL CLEARANCE
EXTENSION LINE
C
LOWER CLEARANCE

** EACH CLEARANCE REMAINS IN EFFECT UNTIL CHANGED BY THE USER



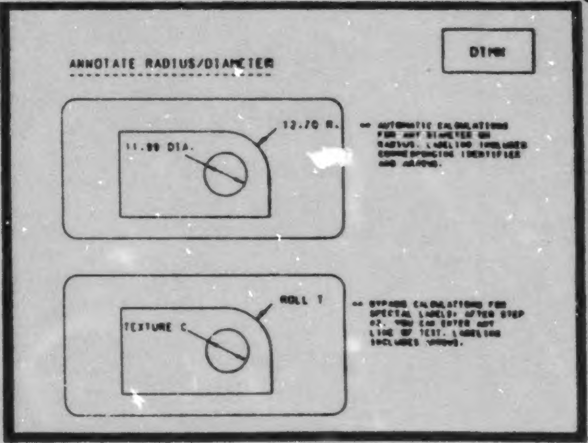
IDENTIFY CURVE OR CIRCLE

DIMN
HORIZONTAL CLEARANCE
HORIZONTAL CLEARANCE
C



ANNOTATE DIMENSIONS

DIMN
ALIGNMENT
1
2
3
4
22.27
17.75
29.44

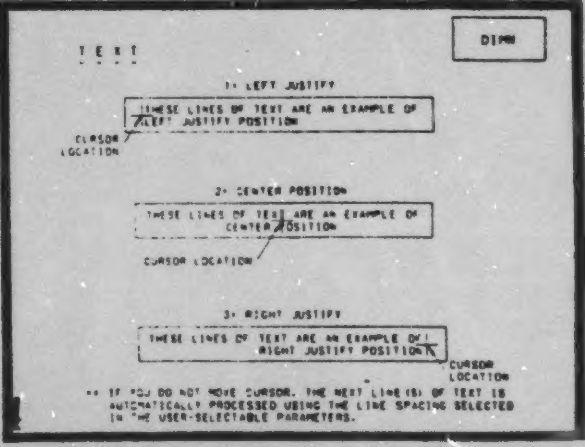


ANNOTATE RADIUS/DIAMETER

DIMN
12.70 R.
11.99 DIA.
ROLL 1
TEXTURE C

** AUTOMATIC CALCULATIONS FOR ANY DIAMETER OR RADIUS. LABELING INCLUDES CORRESPONDING IDENTIFIER AND ARROWS.

** BYPASS CALCULATIONS FOR SPECIAL LABELS: AFTER STEP #2, YOU CAN ENTER ANY LINE OF TEXT. LABELING INCLUDES ARROWS.



T E X T

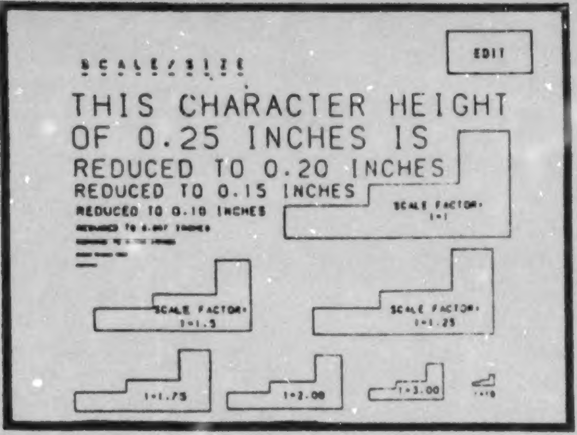
DIMN
1. LEFT JUSTIFY
CURSOR LOCATION
2. CENTER POSITION
CURSOR LOCATION
3. RIGHT JUSTIFY
CURSOR LOCATION

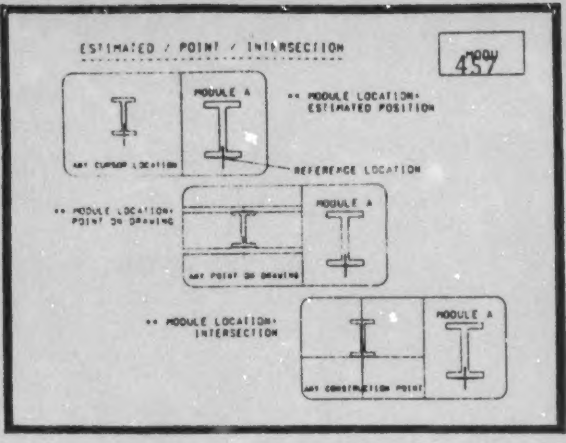
THESE LINES OF TEXT ARE AN EXAMPLE OF LEFT JUSTIFY POSITION

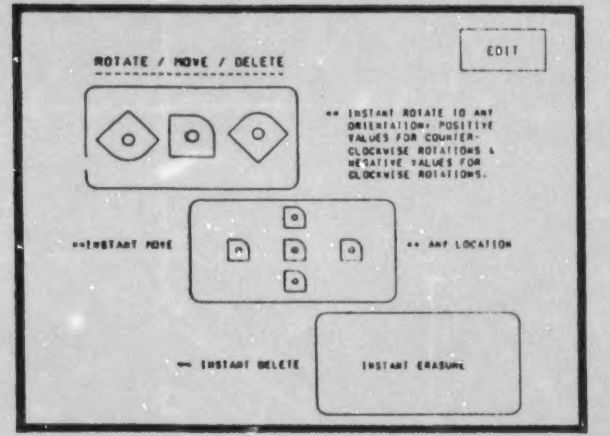
THESE LINES OF TEXT ARE AN EXAMPLE OF CENTER POSITION

THESE LINES OF TEXT ARE AN EXAMPLE OF RIGHT JUSTIFY POSITION

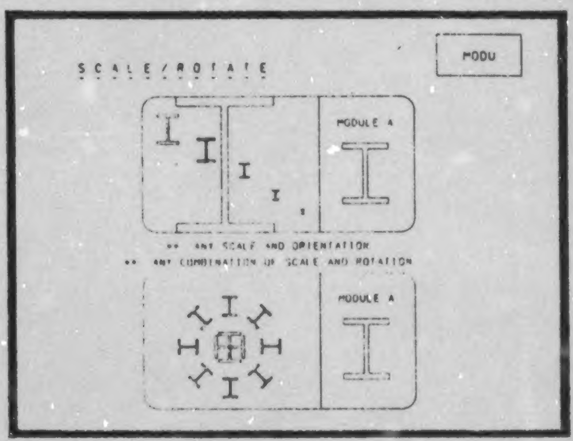
** IF YOU DO NOT MOVE CURSOR, THE NEXT LINE(S) OF TEXT IS AUTOMATICALLY PROCESSED USING THE LINE SPACING SELECTED IN THE USER-SELECTABLE PARAMETERS.

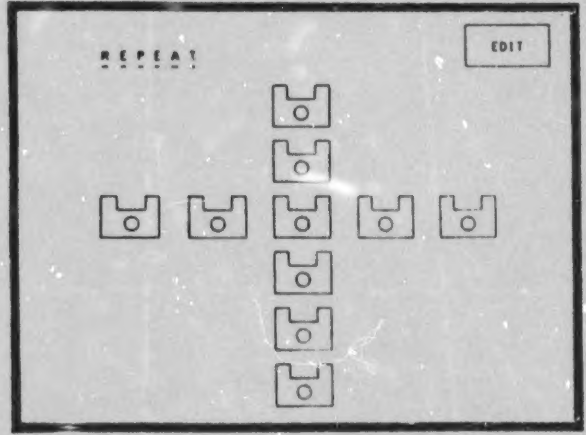

SCALE/SIZE
EDIT
THIS CHARACTER HEIGHT
OF 0.25 INCHES IS
REDUCED TO 0.20 INCHES
REDUCED TO 0.15 INCHES
REDUCED TO 0.10 INCHES
SCALE FACTOR:
1=1
SCALE FACTOR:
1=1.5
SCALE FACTOR:
1=1.25
1=1.75
1=2.00
1=3.00

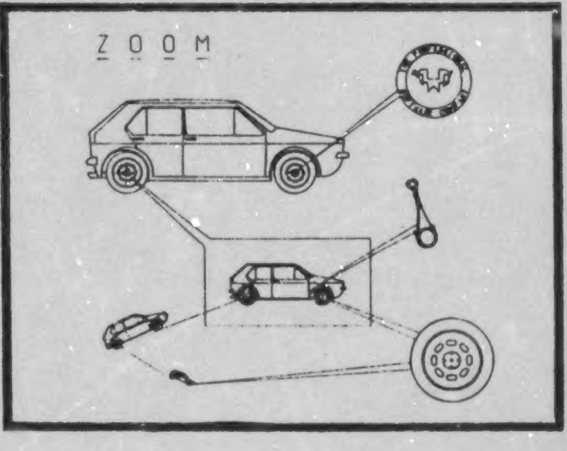

ESTIMATED / POINT / INTERSECTION
MODU
MODULE A
** MODULE LOCATION:
ESTIMATED POSITION
ANY CURSOR LOCATION
REFERENCE LOCATION
** MODULE LOCATION:
POINT ON DRAWING
MODULE A
ANY POINT ON DRAWING
** MODULE LOCATION:
INTERSECTION
MODULE A
ANY CONSTRUCTION POINT

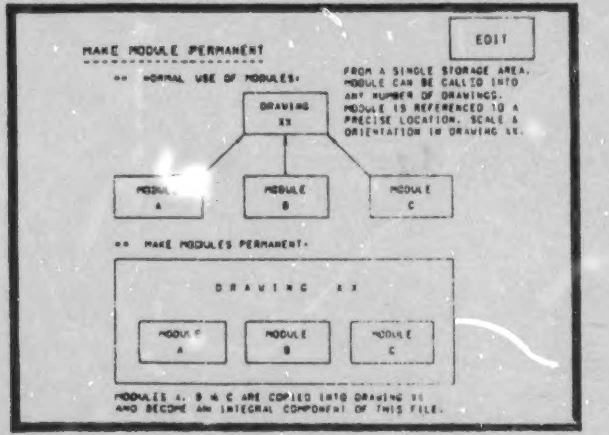

ROTATE / MOVE / DELETE

** INSTANT ROTATE TO ANY ORIENTATION: POSITIVE VALUES FOR COUNTER-CLOCKWISE ROTATIONS & NEGATIVE VALUES FOR CLOCKWISE ROTATIONS.
EDIT
**INSTANT MOVE
** ANY LOCATION
— INSTANT DELETE
INSTANT ERASURE


SCALE/ROTATE
MODU
MODULE A
** ANY SCALE AND ORIENTATION
** ANY COMBINATION OF SCALE AND ROTATION
MODULE A


REPEAT


ZOOM


MAKE MODULE PERMANENT

** NORMAL USE OF MODULES:

FROM A SINGLE STORAGE AREA, MODULE CAN BE CALLED INTO ANY NUMBER OF DRAWINGS. MODULE IS REFERENCED TO A PRECISE LOCATION, SCALE & ORIENTATION IN DRAWING XX.

** MAKE MODULES PERMANENT:

MODULES A, B & C ARE COPIED INTO DRAWING XX AND BECOME AN INTEGRAL COMPONENT OF THIS FILE.
EDIT
DRAWING
XX
MODULE
A
MODULE
B
MODULE
C
DRAWING XX
MODULE
A
MODULE
B
MODULE
C

THE PROFESSIONAL SOFTWARE COMPANY

HOLGUIN & ASSOCIATES, INC.
P.O. Box 12990 El Paso, TX 79912
(915) 581-1171

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Faculty

One instructor in the Mechanical Technology department was assigned to this project. She did the background research, proposed a method for incorporating CAD/CAM, worked with the vendors, and incorporated CAD/CAM into the engineering curriculum. Two faculty members, Jackie Marshall and David Thornburg (of Architectural Technology) were appointed managers of the CAD System and trained faculty during Summer Quarter, 1983. They were assisted by the staff at Hewlett Packard and Holguin and Associates. Mrs. Marshall is currently teaching the CAD course

Computer Numerical Control (CNC)

Numerical control (NC) is a control system for machine tools and some industrial processes in which numerical values which correspond to desired positions of tools or controllers, are recorded on punched paper tape, punched cards, or magtapes so they can be used to control operations automatically. Numerical control machines have been used in manufacturing since 1952. John Pearson at the Massachusetts Institute of Technology developed the first numerically controlled machine for the Air Force. It was designed to produce highly complicated work pieces. Industry did not readily adopt the production equipment because it was costly, large, and difficult to operate. In 1975, the use of microprocessor-controlled numerical control machines led to a more attractive unit.

Computer numerical control (CNC) machines have since replaced virtually all NC machines. They are more powerful because the computer in the machine stores programs and is capable of manipulating them.

Computer-aided parts programming (Capp) is the use of a computer to do the tedious and time-consuming trignometric calculations necessary to prepare programs for machine parts. Programming is based on the Cartesian Coordinate system of geometry. The user can see the part as it is being programmed on the screen. If the programmer sees an error, it can immediately be corrected. One can also check the completed program on the screen or plotter before it is run on a machine. The computer then checks for program errors. This saves machine time, scrap, and accidents. Selected computers designed for educational purposes can actually be used to program any machine tool made. This versatility allows instructors to teach programming of machines which they do not even have in their shop.

Industries that use CNC machines can expect high production repeatability, low waste, high tolerance and safe operations. Industry is depending more and more on automated controllers. Workers which operate the machinery need programming, analyzing and machine control skills.

References

Goldenberg, Naftali and Miri Mishkovsky Instruction of Numerical Control by Computerized Simulation System The Journal Vol 1 (3) January 1983 pp. 87-9,99

Personal Correspondance Jon Stenerson November 1983

Tree, Merle Computerized Numerical Control Program Module One: Introduction to CNC Operation and Programming Division of Vocational-Technical Education Mississippi State Department of Education Jackson, Mississippi 1983

PROGRAM: Machine Tool Operations
INSTITUTION: Fox Valley Technical Institute
1825 N. Bluemound Drive
P.O. Box 2277
Appleton, Wisconsin 54913
(414) 735-5727
CONTACT PERSON: Richard Schmidt
DEGREE: Diploma (Individualized Instruction which takes approximately 72 weeks with approximately 32 hours per week)

History

The Machine Tool Operations faculty saw area industry rapidly moving to CNC machining and Computer-aided parts programming (Capp). They felt that their students needed exposure to computers, programming, and CNC machines. While they had taught NC programming for over ten years, they felt it was time to also offer Capp. The advisory committee, which is composed of representatives of local industry, also approved of the concept and felt that the use of computers in the training of Machine Tool operators was critical to their success on the job.

Program

Training students to operate a wide variety of machine tools skillfully is the major emphasis of the Machine Tool Operation program. The Machine Tool Operation program operates on an "individualized instruction" approach, allowing students to progress through the coursework at their own rates of learning. Some, because of previous experiences in high school or on-the-job, may be able to "test out" or receive advanced standing on many individual modules of instruction. This also allows them the opportunity to complete the machine tool portion of the program in less than 72 weeks. A diploma is awarded to the student after completion of the program.

There are currently 48 students in the year round, day/evening program. The majority of the students are full-time. New students are admitted every six weeks as openings are created by graduating students. Three evening adult extension courses on NC/CNC are also offered. The third course in the sequence utilizes the computer.

Students receive instruction in the use of lathes, milling machines, shapers, grinders, and drill presses. After completion of program requirements, they are ready to seek employment in industries which produce machinery or metal products. With the computer, the students are learning to program CNC machining centers, CNC Lathes, CNC punches even without having the machines in the lab. The computer also allows the student to write the post-processor for a specific machine tool. That is the translator that translates generic geometry information to specific machine tool language. (Most machines have their own language.)

Benefits of having the computers are:

- -increased student interest; (there is a two year waiting list for program entry)
- -cost effective way to teach programming of many different machine tools
- -the ability to try out programs on the plotter instead of on the machine (less tool breakage and scrap)
- -increased industrial interest in the program
- -the exposure helps students gain a much better understanding of NC/CNC and therefore enhance employment opportunities in the machining field.

The Machine Tool Operation program includes the following courses.

MACHINE TOOL OPERATION
Open-ended (approximately 72 weeks)
Average hours per week -- 32

	Hours per Week	Credits
1ST SIX WEEKS		
Blueprint Reading & Sketching	2	*
Machine Shop	24	4
Math I	5	2
2ND SIX WEEKS		
Blueprint Reading & Sketching (continued)	2	*
Machine Shop	24	4
Math I (continued)	5	2
3RD SIX WEEKS		
Applied Math	5	2
Cold Manufacturing Techniques	4	1
Machine Shop	24	4
4TH SIX WEEKS		
Applied Math (continued)	5	2
Cold Manufacturing Techniques (continued)	4	1
Machine Shop	24	4
5TH SIX WEEKS		
Hot Manufacturing Techniques	4	1
Human Relations	5	2
Machine Shop	24	4
6TH SIX WEEKS		
Hot Manufacturing Techniques (continued)	4	1
Human Relations (continued)	5	2
Machine Shop	24	4

*Together count as one credit

	Hours per Week	Credits
7TH SIX WEEKS		
Applied Science	6	2
Machine Shop	24	4
8TH SIX WEEKS		
Applied Science (continued)	6	2
Machine Shop	24	4
9TH SIX WEEKS		
Applied Communications	5	2
Basic Metallurgy	4	1
Machine Shop	24	4
10TH SIX WEEKS		
Applied Communications (continued)	5	2
Basic Metallurgy (continued)	4	1
Machine Shop	24	4
11TH SIX WEEKS		
Basic Mechanical Drafting	4	1
Hydraulics & Pneumatics	3	1
Machine Shop	24	4
12TH SIX WEEKS		
Basic Mechanical Drafting (Continued)	4	1
Hydraulics & Pneumatics (continued)	3	1
Machine Shop	24	4

Basic Mechanical Drafting 421-306
1 credit -- 4 hours per week

Basic Drafting provides the fundamental knowledge of the principles and theories of the language of industry. This course also provides training in basic skills and helps the student develop the degree of accuracy pertinent to the use of drafting room equipment. The units covered entail lettering, dimensions, orthographic projections, geometric constructions, detail, and assembly.

Basic Metallurgy 422-303
1 credit -- 4 hours per week

This course is designed to introduce the Machine Shop student to the science of metals and alloys. The crystalline structure of these metals and the micro-structure are studied, and the affect these structures have on the properties of the metal. Prime consideration is given to heat treatment operations dealing with ferrous metals.

Blueprint Reading & Sketching 421-312

1 credit -- 2 hours per week

This course covers the interpretation of drawings...Isometric and orthographic drawings are studied and simple working drawings are developed. The units covered are dimensions, internal and external threads, holes, bores, fillets, radii, surfaces, planes and gears.

Cold Manufacturing Techniques 420-311

1 credit -- 4 hours per week

Cold Manufacturing is a course designed to provide the student with an understanding of the manufacturing processes related to the metal working industry. It will cover those techniques that are performed on materials in a cold state. The units covered are cold-working metal, forming metal on presses, recent techniques in metal working and polishing and finishing.

Hot Manufacturing Techniques 420-313

1 credit -- 4 hours per week

This course provides the student with basic experiences in welding, foundry, and forging processes. Other areas studied are hot extrusion, hot forming, and steel-making. The student will receive "hands-on" experience in foundry and welding, with project assigments closely related to the machining portion of the program.

Hydraulics & Pneumatics 419-306

1 credit -- 3 hours per week

This course broadly covers fluid hydraulics. Power components and their design, operation, and maintenance are studied.

Machine Shop 420-306

4 credits -- 24 hours per week

The Machine Shop course provides the student with 24 hours a week of theory and practice. A constant check of the students' progress is made as they advance through the assigned units and modules of instructional materials. No set time is allowed to complete specific modules although speed as well as proficiency is encouraged. Competency, the main factor in machine operation, is developed in the course. Minimum standards of proficiency in operation and theory are outlined. When students meet these standards, they advance to the next level of difficulty. Ability to perform, not time, determines when a student completes the requirements for this course. Each student must complete the assigned projects and exercises on the machine tools. These assigments include all of the basic machinery operations required by a machinist. In addition to operating the machines, a student must be able to use common accessories and attachments. Skill in the use of dial indicators, micrometers, scales, and vernier tools is of great importance to each trainee. The student will devote a great deal of time towards the proper care and use of measuring tools. Another important area of training is the development of clean and safe working habits, as well as a healthy attitude towards work. The course requirements include the following units: Measurement, Benchwork, Fasteners, Basic Drill Press, Basic Engine Lathe, Basic Milling Machine, Basic Grinding, Production Turning Machines, Speeds and Feeds, Advanced Lathe, Advanced Milling Machine, Advanced Grinding, Inspection & Quality Control, Basic Numerical Control, Numerical Control Programming, Computer-Aided Parts Programming, and Electrical Discharge Machining.

During the Machine Shop course, the following student record is kept to check students' progress.

Name____________ Date Started____________

SSN____________ Date Left____________

Working at____________ No. Hrs.________ Grade____________

FVTI MACHINE SHOP STUDENT RECORD

	PROJ	INV
1. INTRODUCTION		
A. Introduction		
1. Purchases	____	
2. SAFETY		
A. Shop & Mach Safety		
1.		____
2.		____
3. MEASUREMENT		
A. Rules (Scales)		
1. 1/64 in.	____	____
2. 0.020 in.	____	
3. 0.5 mm	____	
B. Micrometers		
1. OD	____	____
2. Depth	____	
3. ID	____	
C. Verniers		
1. Verniers	____	____
D. Indirect Measure		
1. Ga & Parallels	____	____
E. Angular Measure		
1. Bevel Protractor	____	____
F. Indicators		
1. Indicators	____	____
4. BENCHWORK		
A. Layout		
1. Center Punch	____	____
2. Drill Grind. Ga	____	____
3. Drill & Tap Ga	____	
B. Hacksaws		
1. Drill Grind. Ga	____	____
C. Files		
1. Drill Grind. Ga	____	____
2. Drill & Tap Ga	____	____
D. Screw Threads		
1. Sketch	____	____
2. Thread Size	____	
E. Threading Tools		
1. Drill & Tap Ga	____	____
2. Studs		

	PROJ	INV
F. Coated Abrasives		
1. Drill Gr Ga	____	____
G. Metals & Alloys		
1.		____
I. Chisels		
1. Recondition	____	____
10. BASIC DRILL PRESS		
A. Introduction		
1. Identification	____	____
B. Access. & Proced.		
1. Drill Gr Ga	____	____
2. Dr & Tap Ga	____	
C. Twist Drill Size		
1. Size Ident.	____	____
D. Drill Pt. & Sharp.		
1. Sharpening	____	____
E. Auxilliary Oper.		
1. Holes Cyl. Pt.	____	____
2. Dr pr. Oper.	____	
11. BASIC ENGINE LATHE		
A. Introduction		
1.		____
B. Types		
1. Ident.	____	____
C. Maintenance		
1. Maint. Proc.	____	____
D. Construction		
1. Lathe Parts	____	____
E. Accessories		
1. Acc. Ident.	____	____
F. Cutting Tools		
1. Tool Ident.	____	____
2. Part. Tool from Blank	____	
3. Part. Tool from Preform	____	
G. Speeds and Feeds		
1. Set Sp. & Fd.	____	____
2. Handfeed Fin.	____	
H. Oper. Between Ctr.		
1. In. & Remove Facepl. & Ctr	____	____

Name ____________________

FVTI Machine Shop Student Record

Page 2

	PROJ	INV
2. Setup	____	____
3. Adj. & Oper Sp. & Fd.	____	____
4. Turning Exer. No. 1	____	
5. Lathe Center	____	
6. Test Bar	____	
7. Thd. Exer. 1	____	
8. Fillet Tool	____	
9. Shoulder, Knurl, & Rad. Exer.	____	
10. Lathe Center	____	
11. Taper Exer. 1	____	
I. Operations in Chucks		
1. 4 Jaw exer.	____	____
2. Measuring Tools for Boring	____	____
3. Ream Thru	____	____
4. Ream Blind	____	
5. Arbor Collar	____	
6. Boring Exer.	____	
7. Taper Ring Ga.	____	
8. Tapping Thru	____	
9. Tap Blind	____	
J. Threading		
1. Center Gage	____	____
2. Thd. Exer. 1 (Fin. 11-H-7)	____	
3. Boring Bar, Blind Hole	____	
4. Fitting, Tap and Die	____	
12. BASIC MILLING MACHINE		
A. Types, Nomenclature, etc.		
1.		____
B. Cutters		
1. Mount Cutter	____	____
C. Work Holding & Acc.		
1. Casting Setup	____	____
D. Setup & Operation		
1. Indicate Hole	____	____
2. Parallels	____	
3. Sine Bar	____	
4. V-Blocks	____	
5. Mill. Exer. 1	____	
13. SAWS		
A. Types		
1. Saw Ident.	____	____

	PROJ	INV
B. Saw Blades		
1. Blade Ident.	____	____
C. Setup & Operation		
1. Sample Cuts	____	____
D. Band Machining		
1. Clamp	____	____
E. Welding Blades		
1. Weld Blades	____	____
14. BASIC GRINDING		
A. Pedestal Grinder		
1. Scrdr. Recond.	____	____
2. Chisel Recond.	____	
3. Wheel Dressing	____	
B. Tool Grinding Fund.		
1. Nomenclature	____	____
2. Practice Tool	____	____
C. Drill Grinding Machine		
1. Sharpen Drill	____	____
2.		____
D. Wheels and Safety		
1. Balancing		
E. Surface Grinding		
1. Parallels	____	____
2. V-Blocks	____	____
F. Cylindrical Grinder		
1. Test Bar	____	____
2. Lathe Center	____	
15. PRODUCTION TURNING MACHINES		
A. Types, Nomen, & Oper.		
1. Turret Lathe Nomenclature	____	____
B. Setups & Oper.		
1. Bar Job	____	____
2. Chuck Job	____	
16. SPEEDS AND FEEDS		
A. Speeds		
1. Speed Calc.	____	____
B. Feeds		
1. Feed Calc.	____	____
17. CUTTING TOOLS & MATERIALS		
A. Chipmaking Oper. and Tools		
1. Carbide	____	____
2. HSS	____	
B. Cutting Tool Design		
1.		____

Name ______________________________
FVTI Machine Shop Student Record
Page 3

	PROJ	INV
C. Cutting Tool Material		
1. Tool Mat'l	___	___
21. ADVANCED LATHE		
A. Accessories		
1. Acc. Ident.	___	___
B. Operations Between Ctr. & In Chucks		
1. True Centers	___	___
2. Shoulders, etc.	___	
3. Mandrel Use	___	
4. Nut Mandrel	___	
5. Gang Mandrel	___	
6. Rest/Ctr Hole	___	
7. Taper Ream	___	
8. Gear Spindle	___	
C. Operations on a Faceplate		
1. Casting Align.	___	
D. Misc. Operations		
1. Def. & Hdbk.	___	___
E. Threading		
1. 3-wire Meas.	___	___
2. Thd Mike	___	
3. Acme/Sq. Thd.	___	
4. Acme Gage	___	
22. ADVANCED DRILL PRESS		
A. Types & Work Hold. Device		
1. Radial Drill Controls	___	___
3. Parallel Setup	___	
4. V-Block Setup	___	
5. Angle Plate setup	___	
6. Stops setup	___	
B. Cutting Tools		
1. Drill Press Exer. 22-B-1	___	___
2. Web Thinning	___	___
C. Operations		
1. Drill Press Exer. 22-C-1	___	___
2. Drill Press Exer. 22-C-2	___	___
3. Drill Press Exer. 22-C-3	___	___
4. Spot Drill & Transfer Punch	___	
5. Hand Tapping	___	

	PROJ	INV
6. Power Tapping	___	
23. GEAR PRODUCTION		
A. Gears		
1.		___
24. ADVANCED MILLING MACHINE		
B. Spec. Cutters & Cut. Angles		
1. Spec. Cutter Exer. 24-B-1	___	
C. Dividing Head		
1. Indexing Calc.	___	
2. Indexing Exer. 24-C-1	___	
3. Gear Spindle	___	
27. ADVANCED GRINDING		
A. Tool & Cutter Grinding		
1. End Mills	___	___
2. Plain Mill	___	___
3. Shell Mill	___	___
4. Selection	___	
5. Lathe Center	___	
B. Surface Grinder		
1. Sine Bar	___	___
2. Tool Bit Gage	___	
C. Cylindrical Grinder		
1. Gear Spindle	___	___
D. Internal Grinding		
1. Wheel Selection	___	___
2. ID Gr. Exer.	___	
30. INSPECTION & QUALITY CONTROL		
A. Gage Blocks		
1. Block Selec.	___	___
2. Block Wringing	___	
B. Height Check and Electronic Gaging		
1. Ga. Blk. Check	___	
C. Sine Bar		
1. Angle Check	___	___
D. Inspection		
1. V-Block Inspect.	___	
33. BASIC NUMERICAL CONTROL (N/C)		
A. Introduction		
1. Coordinates	___	___
B. Manual Data Input (M.D.I.)		
1. Manual Oper.	___	___

Name ____________________
FVTI Machine Shop Student Record
Page 4

PROJ INV

C. N/C Tape Machining
  1. Test Pattern ____
  2. Test Part ____

34. TOOLMAKING
  A. Precision Hole Location
    1. Drill Location ____
    2. Bore Location ____
    3. Shaft Support ____
  B. Fits
    1. Drill Fits ____
    2. Bore Fits ____
  C. Jig & Fixture Construction
    1. Selection ____

36. N/C TAPE AND TAPE CODING
  A. N/C Tape
    1. Read Tape ____ ____
    2. Punch Tape ____
    3. Write Program ____
  B. N/C Programming Fundamentals
    1. Project #1 ____ ____
    2. Project #2 ____
    3. Project #3 ____

43. BROACHING
  A. Basics
    1. Identification ____ ____
    2. Broach Nomen. ____
    3. Setup to Broach ____

44. COOLANTS
  A. Cutting Fluids
    1. Mix Coolants ____ ____

____ Tool Checks Numbered ____ Issued ____________________ 19__ by ______

____ Tool Checks Numbered ____ Returned ____________________ 19__ by ______

____ Check out sheet completed on ____________________ 19__

Equipment

The Machine Tool Operator program currently owns equipment produced by Numeridex (241 Holbrook Drive, Wheeling, IL 60090). The equipment does several things which are useful in the lab. It can aid the manual programmer in determination of X,Y coordinate pairs related to positioning operations. It is interactive and allows the user to choose several options which are displayed on the video screen, the line printer, and/or retained on disk. It also relieves the manual programmer of the time-consuming task of determining cutter positons when doing area clearance operations. It automatically calculates cutter postions for any regular polygon up to 25 sides. Many other features are included with the machine including the ability to draw an actual slide or tool tip motion directly from the machine control tape stored on a floppy disk. Critical areas can be magnified up to 800 times for detailed path analysis.

Faculty Development

All the machine tool instructors attended a four day workshop coordinated by the Numeridex Company. Individual study by each instructor was also necessary for mastery of the equipment.

Placement

Placement data is available for the 1982 graduating class. There were 16 graduates, 13 of whom responded to the follow-up survey. Nine were employed in a related occupation and two were still seeking employment. Their median monthly salary was $1200. Job titles and places of employment included:

Machine Operator	Manufacturing Co.
Machinist	Manufacturing Co.
Tool and Die Operator	Manufacturing Co.
Tool Maker	Manufacturing Co.
Pattern Maker	Manufacturing Co.
Machinist/Assembler	Manufacturing Co.
Machinist	Manufacturing Co.

PROGRAM: Computerized Numerical Control-Upgrade Program
INSTITUTION: Itawamba Junior College
653 Eason Boulevard
Tupelo, Mississippi 38801
(601)842-5621
CONTACT PERSON: Rannie Barnett
DEGREE: Certificate of Completion
Phase 1,2,and 3 = 39 hours
PROGRAM BEGAN: September 1982

History

The State Department of Education, Vocational/Technical Division is working through the Industrial Services branch of Itawamba Junior College (IJC) to upgrade the skills of employees within a five-county area in Northeast Mississippi. Three mobile classrooms were constructed for computerized numerical control (CNC) production equipment in response to the needs of area industrial personnel. These 60 foot long units house numerous CNC trainers. They are utilized to teach employees of manufacturing plants to program and operate the complex and expensive CNC production machinery that is rapidly replacing manually operated equipment.

The first use of the CNC mobile classroom was in Tupelo, Mississippi where 16 engineers, supervisors, and qualified machine operators from the Power Tool Division of Rockwell International enrolled in the program. It was designed to familiarize them with the programming and operation of CNC production equipment. The conversion to computerized numerical control production equipment at Rockwell has spanned a three-year period. To upgrade the skills of their present employees, Rockwell enrolled their personnel in the CNC program taught by Merle E. Tree of the IJC Industrial Services Division located on the Tupelo Compus. Tree's experience included many years in electronics in the Navy as well as instruction in electronics, analog and digital computers, electrohydraulics, electro-pneumatics, and servo-drive mechanisms.

The mobile units are part of a cooperative effort by junior college to meet the needs of new and expanding industries in the state. They were constructed by students in building trades and welding classes at the various branches of Gulf Coast Junior College. The students also built the frames for five other trailers to be used as mobile teaching facilities in electronics, instrumentation, industrial maintenance, hydraulics and pneumatics. Because of the units, particularly the CNC trailers, industrial personnel across the state -- like the 16 Rockwell International employees -- will be a part of the high technology revolution that is Mississippi's present and future.

The recent death of Merle E. Tree left a tremendous void. His colleagues called him an extraordinary man and educator, a very special and unique individual. He touched countless lives during his period of employment by Itawamba Junior College. He was the pioneer instructor in computerized numerical control and also assumed the same "trailblazing" role in robotics. The information contained in this section is a tribute to Merle E. Tree, both a fine man and educator.

THE PROGRAM

The curriculum enables the registrants to receive 9 hours of instruction on the plotter, 15 hours on the lathes, and 15 hours on the milling machine. There is flexibility in the number of hours depending on the needs of the employer. Courses are taught two hours each day, two days per week. Again, the length of the course can vary according to the requirements of the employer.

Prospective students of the CNC program should have some familiarity with basic shop math and the fundamentals of trigonometry. The course is generally designed for industrial personnel including supervisors, foremen, draftsmen, industrial engineers, and experience machinists.

The curriculum was developed for Rockwell as a three-phase program Course outlines for those phases follow.

COMPUTERIZED NUMERICAL CONTROL

PHASE I

Course Outline

39 Hours

I. Introduction to Pitsco Plotter Training Program

   A. Basic Numerical Control
      1. Introduction to Numerical Control
      2. Numerical Control Described
      3. History of Numerical Control
      4. Advantages of Numerical Control
      5. General Numerical Control Operation Procedures for Pitsco Plotter

II. Fundamentals of Numerical Control

   A. Positive and Negative Numbers
   B. The X and Y Axes

III. Auxiliary Control Functions

   A. M Codes
   B. G Codes
   C. Absolute and Incremental Programming

IV. Modes of Control

   A. Point-to-Point
   B. Continuous-Path or Contour Control
   C. Incremental Positioning
   D. Absolute Positioning
   E. Circular Interpolation

V. Programming

   A. The Programmer
   B. Writing Program Manuscripts
   C. Content Material
   D. Manuscript Formats

VI. Tape Preparation

   A. NC Input Medium
   B. Tape Readers
   C. Tape Codes
   D. Tape Preparation Equipment

COMPUTERIZED NUMERICAL CONTROL

PHASE II

I. Introduction to EMCO Lathe

II. EMCO Lathe Technical Data

III. Machine Tool Coordinates

IV. Code Description

  A. M Codes
  B. G Codes

V. Programming Data Format

  A. Program Manuscripts
  B. Programming

VI. Manual Data Input

VII. Teletype Tape Operation

VIII. Alarm Signs

IX. Tool Positioning

  A. Zero Points on X and Z Coordinates

X. Program Exercises

COMPUTERIZED NUMERICAL CONTROL

PHASE III

I. Introduction to Terco Milling Machine

II. Technical Data

III. Machine Tool Coordinates

IV. Code Descriptions

V. Loading the Program

VI. Dumping the Program

VII. Indicator Lamps

VIII. System Controls

IX. Programming Controls

X. Other Controls

XI. Programming Exercises and "Hands On" Equipment

In addition, through a cooperative effort between Itawamba Junior College, Mississippi State Department of Education and the College of education at Mississippi State University, curriculum materials were developed in a four module format which can be used for general instruction in the mobile units. These modules were designed for group instruction or individualized self-study.
The four modules are titled:

- Module One - Introduction to CNC Operation and Programming
- Module Two - Plotter
- Module Three - Lathe
- Module Four - Milling

The objectives and content of these modules are listed below.

Module One - Introduction to CNC Operations and Programming

Objectives:

- Identify the components of the CNC Training program.
- Recall the features of CNC equipment.
- Apply the rectangular coordinate system to the operation of the PITSCO plotter and EMCO lathe.
- Find the absolute and incremental coordinates of points which are listed.
- Identify the "G" and "M" codes for the PITSCO plotter and EMCO lathe.
- Follow a circular interpolation demonstration on the PITSCO plotter.
- Follow a turning and threading demonstration of the EMCO lathe.
- Follow a point-to-point demonstration on the PITSCO plotter.
- Follow a continuous-path or controuing-control demonstration on the PITSCO plotter.
- Follow a demonstration of the "I" and "J" coordinates (circular interpolation) on the PITSCO plotter.
- Explain the differences between the PITSCO plotter and the EMCO lathe.

Time required is 2-1/2 hours. (For specific content, contact Itawamba Junior College.)

Module Two - Plotter

Objective:

The objective of this module is to develop proficiency in using the three-axis plotter.

1) Basic Numerical Control
2) The Fundamentals of Numerical Control
3) Auxillary Function Controls
4) Absolute and Incremental Programming Modes
5) Preparation of Numerical Control Tapes, Tape Readers, and Tape Codes

Time required is eight hours. (For specific content, contact Itawamba Junior College.)

Module Three - Lathe

Objectives:

Apply feed and speed data.
Visualize the coordinate system as it applies to the lathe.
Apply programming data format and code description for the lathe.
Recall magnetic tape operations.
Recognize alarm signs.
Apply tool positioning for program exercises.
Apply manual data input.
Practice programming and operating the lathe.

Time required is 15 hours. (For specific content, contact Itawamba Junior College.)

Module Four - Mill

Objectives:

Develop a capability in the programming techniques of the three-axis TERCO CNC 1000 Milling Machine.

Time required is 15 hours. (For specific content, contact Itawamba Junior College.)

Equipment

The mobile units are used as lecture areas as well as working areas. Contained in the trailers are the CNC trainers which include one PITSCO NCS77 plotter, four EMCO Compact 5 CNC lathes, and one TERCO CNC 1000 milling machine working in conjunction with a teletype printer, tape punch, photoelectric tape reader, and audio cassette playback.

Faculty

The faculty were trained in electronics and computers. They received training on the equipment from the supplier.

Placement

This program is developed to train industrial personnel. It was designed to serve industry in the five-county area served by Itawamba Junior College by upgrading the skills of industrial workers. Therefore, placement is not part of their mission.

Robotics

The first robot was installed at a General Motors plant in 1961. During the 1960's and 1970's however, robots were not extensively used in industry. Recently, they have become integral components in a variety of manufacturing and industrial concerns. Their appearance in industry was advanced in the 1980's because of increasing labor costs, advances in electronics and the talent of two engineers: George Devol and Joseph Engelberger.

Today, approximately 55% of the robots currently in use are in the automobile industry. Other settings include factories, offices and institutions (such as hospitals, schools, and prisons), space, undersea investigations, mining, nuclear plants, home, agriculture, construction and the military.

Many people confuse robots with machines that can move parts. The robot differs from a parts transfer machine in that its motion pattern can be reprogrammed by adjusting either the physical mechanisms of non-servo robots or the software in the computer.

> "The robot is defined as a programmable machine which is designed to move an end-of-arm tool, gripper and/or sensor to a precise point in the work environment by a given sequence of motions and in so doing, accomplishes work such as moving parts, assembling systems, and/or performing inspections on a repetitive basis without human intervention"
> (Rothscild, Unterberg & Towbin, 1983)

Education and Training

If Michigan is any indication of the national workforce, the largest single group of jobs created in the field of robotics will be Robotic Technicians (See Table 1): individuals who install, qualify, troubleshoot and maintain robots (Hunt and Hunt, 1982).

Table 1

Potential Cumulative Direct Job Creation in Michigan by Occupation Due to Robotics, 1990

Occupation	Estimated Employment Range	
	Low	High
Engineers	884	3,537
Robotics Technician	1,810	4,469
Other Engneer Tech	91	360
Other professionals	159	637
Managers	241	966
Sales Workers	108	433
Clerical Workers	472	1,888
Skilled craft and rel.	354	1,418
Semi-Skilled metal working operatives	211	843
Asemblers and others	677	2,709
Service Workers	27	110
Laborers	91	367
Total	5,125	17,737

(Hunt and Hunt, 1982)

Two-year postsecondary institutions are trying to develop programs to keep up with this expected demand.

According to Ashley, Abram, Konopka and Carrico, (1983) robotics technicians will need to possess a broad range of skills in electromechanics. They will need to prepare, read, interpret and/or apply service schedules, installation and instruction sheets, service orders, record forms, blueprints, block diagrams, logic diagrams, ladder diagrams, power system diagrams, computer logic and programming languages, programming flow diagrams, electric/electronic schematics, control flow diagrams, technical writing, technical revisions and updates, and electrical/wiring codes.

Technicans will install programs, adjust, troubleshoot, and/or operate pneumatic logic controllers, cam actuated controllers, programmable logic controllers, digital programmers and controllers, electronic squencers and sensors, electronic test equipment, transducers and interface devices, microprocessors, industrial finishing devices on robots, materials handling devices on robots, industrial welders on robots, encoders, laser inspection equipment and devices.

They will need to remove, install, repair, and/or service hydraulic pumps, control valves, accumulators, actuators, gauges, line filters, pneumatic equipment, electrical power conductors, electronic drives, automatic lubrication systems of robots, mechanical drives and linkages, robot end effectors, and transfer line devices.

Technicians will read, write, interpret, process and/or file technical reports, business letters, legal contracts, financial forms, budget documents, estimates of cost, time and materials, and charts, graphs and diagrams.

It can be assumed that techncians will come into contact with a variety of company personnel and customers and therefore need to be proficient in communication skills, both oral and writing.

In general, there are two ways in which the robotics technician will encounter the computer (Schilling, 1983). The first will be at the user level where the system control programs have already been written. The technician will monitor and set up the robot work station with the appropriate commands. The computer is the tool that will need to be set into a sequential order to fit the job task to be performed. Usually a keyboard or a keypad is used for the input. This assigns the robot prescribed motions. As the robot arm moves, the computer will store the data that describes the path and operations performed.

The second way in which the technician encounters the computer is in the initial applications stage and in the troubleshooting stage of servicing the robot. At this level, the technician needs to be a programmer. The program will be written in the particular language that the robot understands. The technician must also be able to troubleshoot, meaning that he/she will need to understand how the components function at all levels in order to interpret the entire system.

A list was developed at Western Michigan University which includes topics that should be included in a Robot Technology education program. It is included in Appendix C.

References

Achley, W. R. Abram E. Knoapka Robotics Programs Columbus, Ohio: The national Center for Research in Vocational Education 1983

Hunt, H.A. Hunt, T. L. Robotics: Human Resource Implicationa for Michigan Kalamazoo, Michigan: W. E. Upjohn Institute for Employment Research 1982

Rothschild, L. F. Unterberg T. Towbin Robotics Industry Research Report

Schilling, William The Use of Computers in Vocational Instruction: Robotics Arlington Virginia: American Vocational Assocation, 1983

Sitkins, F. Z. State-of-the-Art in Robotic's Education Presentation at the 13th International Symposium on Industrial Robots. Chicago Illinois 1983

PROGRAM: Robotics Technican Program
INSTITUTION: Minneapolis Technical Institute
1415 Hennepin Avenue South
Minneapolis, Minnesota 55403
(612) 370-9477
CONTACT PERSON: Craig Froke
DEGREE OPTIONS: Take a few courses for technical content OR Associate Degree (two years/8 quarters)
DATE BEGAN: Fall 1983

History

In 1982 an advisory committe in school recommended that a separate program in robotics be established which would utilize the curriculum in electronics and computer science, in addition to specific robotics courses that would be taken during each quarter.

At the time of this writing, the program was in its first quarter. It is expected that changes in the program will occur after its first year of operation. Those changes will not be included in this report.

Advisory Committee

A committe of industry representatives and educators involved in robotics applications are responsible for recommending program policies and curriculum. They have been actively involved in intiating and developing this relatively-new program.

The Program

The Robotics Technology program is a two-year occupational program designed to prepare technicians for robotics design and research, robot applications, installation, programming, "Start-Up" procedures, customer service, trouble shooting and maintenance. The robot technican needs an understanding of the integrated systems represented by robots and flexible, programmable, automation through the application of hydraulics, pneumatics, mechanics, electricity, electronics and computers as they relate to robotics and computer aided design and manufacturing (CAD/CAM). Several options of the associate degrees are available in cooperation with Minneapolis Community College.

There are three degree options which a student may choose to receive a degree. See Figure 1 for a definition of those options.

FIGURE 1

ROBOTICS TECHNOLOGY OPTIONS

MINNEAPOLIS TECHNICAL INSTITUTE/MINNEAPOLIS COMMUNITY COLLEGE

Option 1	Option 2	Option 3	Option 4
MTI Robotics Technology Certificate	MTI Robotics Technology Certificate + MCC Associate of Applied Science Degree	MTI Robotics Technology Certificate + MCC Associate of Science Degree	MTI Robotics Technology Certificate + MCC Associate of Art Degree
MTI Robotics Technology Program 2,640 Hours + 19 MCC Credits	MTI Robotics Technology Program 2,640 Hours + 19 MCC Credits	MTI Robotics Technology Program 2,640 Hours + 19 MCC Credits	MTI Robotics Technology Program 2,640 Hours + 19 MCC Credits
	12-17 Additional MCC Credits To Meet A.A.S. Degree Distribution Requirements	27-32 Additional MCC Credits To Meet A.S. Degree Distribution Requirements	39-48 Additional MCC Credits To Meet A.A. Degree Distribution Requirements

The unique feature of this program is that it is an evening program only. The recommendation for this came straight from the advisory committee. They saw a need for a program which would retrain area industrial workers. Employers have either been sending their employees to be retrained or have recommended that they receive this training on their own.

Advanced standing and credit is given to many of these students. For example, a manufacturing engineer could proceed directly to the specialized robotics courses and receive a degree.

As a result of this orientation, the student population is older than the traditional student body. The average student is 30-40 years old.

At this time, there is not a training laboratory in the school. Equipment is very expensive and donations were not easily available. Students and faculty are therefore using the equipment that is already in the city at area industries. The goal is to have an operational laboratory within the school by July 1, 1984. At this time, the ties to industry are critical for the specific applications that employers need their employees, or future employees, to learn. A critical part of the program is therefore to place every student at a number of industry sites so that they may experience a wide range of equipment and competencies which are required in a variety of operations.

A formal internship is conducted during the last quarter so that the student may obtain concentrated training with one particular system. Often, the student will be hired by that employer, but there is no requirement for the employer to do so.

The following is a Robotics Technology Course Outline and Competency Skill Listings for the Robotics Courses.

PROPOSED ROBOTICS TECHNOLOGY COURSE OUTLINE
(Revised 02/08/83)

Quarter 1

Basic DC Circuits - 120 Hours
Introduction to Fluid Power-Hydraulics - 120 Hours
Applied Algebra 1 - (5 credits MCC)
Introduction to Robotics - 60 Hours

Quarter 2

DC and AC Electronics - 120 Hours
Introduction to Fluid Power-Pneumatics - 120 Hours
Applied Algebra 2 - (5 credits MCC)
Robotics in Industry - 60 Hours

Quarter 3

Solid State/Digital Electronics - 240 Hours
Intermediate Algebra & Trigonometry - (5 credits MCC)
Robotics Construction - 60 Hours

Quarter 4

Computer Logic/Introduction to Microprocessors - 240 Hours
Introduction to Physics #100 - (4 credits MCC) or College Physics #131 and 132 (5 credits MCC)

Robotics Systems - 60 Hours

Quarter 5

Electronic Controls/Ladder Diagrams - 240 Hours
Mechanisms/Drives/Linkages - 60 Hours
Robotics Programming - 60 Hours

Quarter 6

Electro Mechanical Systems - 300 Hours
Manufacturing Materials & Processes - 60 Hours

Quarter 7

Microprocessors/Programmable Controllers - 240 Hours
Stepper Motor Robots - 120 Hours

Quarter 8

Robotics Applications - 180 Hours
Industrial Robotics Applications (or Internship) - 180 Hours

ROBOTICS TECHNICIAN PROPOSAL

COMPETENCY (SKILL) LISTINGS FOR ROBOTICS COURSES

Minneapolis Technical Institute   Performance Profile Worksheet

Cluster: Energy & Power   Program: Robotics Technology
Manager: Jules Reed   Course: Basic DC Circuits #1.1
2 Hours/Day for 12 Weeks   Page 1 of 1
Total Course 120 Hours   Prep. by: Craig Froke 11/08/82

	Skills	Hours
01	Describe atomic theory as it applies to electricity.	10
02	Describe elect. charge/current/voltage & resistance.	5
03	Identify AC & DC circuits.	6
04	Identify and use various hand tools.	3
05	Use soldering iron to replace components and splice wire.	10
06	Describe Ohm's law/power dissipation and elect. safety	10
07	Describe and construct series circuits/apply Ohm's law.	15
08	Describe and construct parallel circuits/apply Ohm's law.	10
09	Construct and Diagnose series-parallel circuits.	15
10	Identify/construct and diagnose voltage & current dividers.	15
11	Identify and use different types of analog meters.	15
12	Identify and use digital meters.	6

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power Program: Robotics Technology
Manager: Jules Reed Course: Fluid Power-Hydraulics #1.2
2 Hours/Day for 12 Weeks Page 1 of 2
Total Course 120 Hours Prep. by: Craig Froke 12/15/82

Description: Basic concepts, components and circuits used in industrial hydraulic systems: Basic fluid laws, transmission of fluid power, work and pressure relationships, hydraulic supplies, operation and use of various types of control valves and cylinders and basic hydraulic systems.

	Skills:	Hours
01	Apply principles: work/power/force/pressure for hydraulics.	2
02	I.D. advantages/disadvantages of hydraulics as power transmission.	1
03	Identify hydraulics safety precautions.	1
04	Explain physical differences: solids, liquids, and gases.	1
05	Differentiate fluid flow/velocity/pressure drop in hyd. circuit	1
06	Analyze variations: flow/velocity/pressure drop in hydraulic circuit	2
07	Explain relationship: work, force, pressure.	1
08	Apply basic fluid power formulae.	2
09	Diagram basic hydraulic circuit using standard symbols	2
10	Assemble & test hydraulic system from circuit diagram	10
11	Identify uses of pressure control valves.	1
12	Identify operation of pressure control valves.	2
13	Install pressure control valves in hydraulic circuit.	3
14	Diagnose/repair pressure control valves.	2
15	Identify purposes of directional control valves.	2
16	Select directional control valves for specific application.	2
17	Install directional control valve for specific application.	2
18	Diagnose/repair directional control valves.	3
19	Identify principles of operation of flow control valves.	1
20	Install flow control valves in hydraulic circuit.	2
21	Describe basic types of flow control circuits and uses.	2
22	Identify types of hydraulic pumps & advantages/disadvantages.	2
23	Diagnose hydraulic pump malfunctions, determine prob. cause.	2
24	Diagnose/repair basic pumps.	4
25	Install hydraulic pumping unit into hydraulic circuit.	4
26	Identify various types of hydraulic actuators.	1
27	Diagnose/repair actuators.	3
28	Select hydraulic actuators for specific application.	2
29	Describe various types of hydraulic fluids and fluid bases.	2
30	Select appropriate hydraulic fluid for hydraulic system.	1
31	Select proper storage facilities for hydraulic fluids.	1
32	Describe purposes of filtration in hydraulic system.	1
33	Identify function & purpose of hydraulic heat exchangers.	1
34	Select seals/fittings/lines for various applications.	4
35	Connect basic hyd. system using proper tools and materials.	20

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
2 Hours/Day for 12 Weeks
Total Course 120 Hours

Program: Robotics Technology
Course: Fluid Power-Hydraulics #1.2
Page 2 of 2
Prep. by: Craig Froke 12/15/82

36	Determine safety factors involved in hydraulic system.	1
37	Describe the effects of excess pressure and fluid velocities.	1
38	Perform preventive maintenance procedures - hydraulic system.	12
39	Diagnose common malfunctions in hydraulic system, and repair.	12

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
1 Hours/Day for 12 Weeks
Total Course 60 Hours

Program: Robotics Technology
Course: Introduction to Robots #1.4
Page 1 of 1
Prep. by: Craig Froke 11/04/82

	Skills:	Hours
01	Define industrial robots.	2
02	Identify basic components of robot.	8
03	Describe robot manipulator and its function.	4
04	Describe robot controller and its function.	4
05	Describe robot power supply and its function.	4
06	Identify purpose and basic operation of pick and place robot.	6
07	Identify purpose and basic operation of servo controlled robot.	8
08	Identify purpose and basic operation of intelligent robot.	8
09	Describe major functional parameters of industrial robot.	16

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power Program: Robotics Technology
Manager: Jules Reed Course: DC & AC Electronics #2.1
2 Hours/Day for 12 Weeks Page 1 of 1
Total Course 125 Hours Prep. by: Craig Froke 11/08/82

	Skills:	Hours
01	Describe and apply Kirchoff's voltage and current laws.	10
02	Identify conductors and insulators & describe use.	4
03	Identify resistor/color code and power rating.	6
04	Identify and use different batteries and voltage sources.	10
05	Describe and use magnetism and magnetic units.	6
06	Explain and apply electro-magnetic induction.	10
07	Define inductance/inductive reaction/inductive circuits.	11
08	Identify and use inductive circuits.	10
09	Define capacitance/cap. reactance/capacitive circuits.	11
10	Identify and use capacitive circuits.	10
11	Identify and use LR and RC time constants/waveforms.	8
12	Identify and use R, L & C in AC circuits.	10
13	Identify and use resonant circuits.	4
14	Identify and use filtering circuits.	4
15	Describe types of CRT's.	4
16	Operate AC and DC Power supplies.	4
17	Operate and measure with triggered oscilloscope.	3

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
2 Hours/Day for 12 Weeks
Total Course 120 Hours

Program: Robotics Technology
Course: Fluid Power-Pneumatics #2.2
Page 1 of 1
Prep. by: Craig Froke 12/15/82

Description: Fluid power fundamental laws, air supplies and conditioning instrumentation, pressure controls, actuators and valves, typical industrial control systems, electrical actuators are used with industrial electrical controls to develop electro-pneumatic systems.

	Skills:	Hours
01	Describe use of pneumatic power in robots.	1
02	Identify advantages and disadvantages of compressed air power.	2
03	Lay out basic pneumatic distribution system using block diagram.	2
04	I.D. basic components in pneumatic system, describe function.	2
05	Connect regulators, filters, and lubricators into pneumatic system.	9
06	Diagnose/repair/test filters, regulators, lubricators.	6
07	Describe relation: pressure vs. air flow & flow vs. pressure drop.	4
08	Identify principles of operation of basic valve designs.	5
09	Connect basic air valves into pneumatic system.	12
10	Diagnose/repair air control and pressure valves.	9
11	Identify several uses for pneumatic valves.	1
12	Identify various types of pneumatic actuators.	2
13	Apply types of pneumatic actuators for proper mechanical advantages.	2
14	Diagnose/repair actuators.	7
15	Calculate pneumatic actuator input and output horsepower.	2
16	Explain relationship of RPM/torque/horsepower/input pressure.	2
17	Describe proper storage/handling procedures for actuators.	1
18	Diagram basic pneumatic circuits using standard symbols.	2
19	Connect pneumatic system using schematic.	10
20	Demonstrate difference: power circuitry and control circuitry.	2
21	Identify parallel and series circuit design.	2
22	Apply principles of force/area/pressure in pneumatic systems.	2
23	Apply general gas law to pneumatics.	2
24	Relate the general gas law to Charles' and Boyles' laws.	2
25	Identify various types of compressors and describe use.	2
26	Determine compressor input/output characteristics.	2
27	Describe prime movers used to operate air compressors.	1
28	Select air compressor for specific application.	2
29	Connect industrial air system.	20
30	Identify variations in air distribution systems and purposes.	2

Minneapolis Technical Institute — Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
1 Hour/Day for 12 Weeks
Total Course 60 Hours

Program: Robotics Technology
Course: Robotics in Industry #2.4
Page 1 of 1
Prep. by: Craig Froke 11/04/82

	Skills:	Hours
01	Identify major uses of robots in industry.	8
02	Describe specific applications of industrial robots.	8
03	Describe history of industrial robots.	6
04	Identify future aspects of industrial robots.	8
05	Identify function of robotic technician.	10
06	Identify career opportunities of robotic technician.	10
07	Describe implications of robots replacing humans in industry.	10

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
4 Hours/Day for 12 Weeks
Total Course 240 Hours

Program: Robotics Technology
Course: Solid State/Digital Electronics
Page 1 of 1 #3.1
Prep. by: Craig Froke 11/09/82

	Skills:	Hours
01	Identify and use Class A amplifiers.	5
02	Identify and use Class B amplifiers.	5
03	Identify and use Class C amplifiers.	5
04	Identify and use field effect transistors.	10
05	Identify and use hybrid parameters.	5
06	Predict the high frequency effects of circuits.	5
07	Describe the different integratd circuits types.	15
08	Identify op. amp applications.	15
09	Identify negative feedback in amps.	10
10	Identify positive feedback in oscillators.	5
11	Identify and use I.C. voltage regulators.	10
12	Define frequency domain.	5
13	Identify methods of modulation.demodulation for data transmission.	5
14	Identify and use DBS for power and voltage measurements.	2
15	Identify and use binary octal and hexidecimal number system.	10
16	Identify and use various display code systems.	10
17	Define arithmetic circuits.	10
18	Identify and use basic logic gates.	20
19	Identify and use proper methods of simplifying logic circuits.	15
20	Identify and use multivibrators.	15
21	Define counter techniques.	10
22	Identify and use thyristors.	10
23	Identify and use light active devices.	10
24	Identify and use 555 timers.	10
25	Analyze and repair circuits in industrial applications.	35
26	Identify and use frequency counters.	3

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
1 Hour/Day for 12 Weeks
Total Course 60 Hours

Program: Robotics Technology
Course: Robot Construction #3.3
Page 1 of 1
Prep. by: Craig Froke 11/04/82

	Skills:	Hours
01	Identify robot components and their use in system.	4
02	Construct mechanism for single arm robot.	12
03	Construct mechanism for double arm robot.	12
04	Construct mechanism for box arm robot.	12
05	Alter robot configurations to fit industrial situation.	20

Minneapolis Technical Institute   Performance Profile Worksheet

Cluster: Energy & Power   Program Robotics Technology
Manager: Jules Reed   Course: Computer Logic   #4.1
4 Hours/Day for 12 Weeks   Page 1 of 1
Total Course 240 Hours   Prep. by: Criag Froke   11/09/82

	Skills:	Hours
01	Identify special counters & registers.	20
02	Identify input/output methods.	20
03	Define D/A & A/D conversion.	20
04	Identify memories & storage mediums.	20
05	Define digital arithmetic principles.	20
06	Identify digital timing systems.	20
07	Use test equipment.	4
08	Prototype circuits.	16
09	Operate microprocessor system.	30
10	Apply complex circuits to industrial application.	25
11	Define different op amps.	20
12	Define phase lock loops.	20
13	Define active filters.	5

Minneapolis Technical Institute Performance Profile Workheet

Cluster: Energy & Power
Manager: Jules Reed
1 Hour/Day for 12 Weeks
Total Course 60 Hours

Program: Robotics Technology
Course: Robotic Systems #4.3
Page 1 of 1
Prep. by: Craig Froke 11/04/82

	Skills:	Hours
01	Demonstrate use of pneumatics in robots.	10
02	Describe use and basic operation of robot controllors.	15
03	Robot of hydraulics/pneumatics/mechanics/electronics interface.	10
04	Program robot to perform simple task.	15
05	Identify robot sensory system.	5
06	Demonstrate robot sensory systems.	5

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
4 Hours/Day for 12 Weeks
Total Course 240 Hours

Program: Robotics Technology
Course: Electronic Controls #5.1
Page 1 of 1
Prep. by: Craig Froke 11/09/82

	Skills:	Hours
01	Identify electronic control & measurement safety precautions.	2
02	Use electromechanical relays in control systems.	2
03	Use solid state relays in control systems.	3
04	Describe operation of DC motors.	2
05	Describe operation of DC generators.	2
06	Use electronic control systems to regulate series motors.	6
07	Use electronic control systems to regulate shunt motors.	6
08	Describe operation of stepping motors.	3
09	Program stepping motors to control a specific process.	7
10	Diagnose motor and motor control malfunctions.	6
11	Identify & describe operation of photoelectric control devices.	2
12	Use photoelectric control devices in industrial applications.	6
13	Describe operation of electronic temp. measure/control devices.	3
14	Use temperature measurement/control devices.	8
15	Identify & describe operation of electronic gas/humidity sensors.	2
16	Use electronic gas/humidity sensors in industrial applications.	6
17	Describe electronic pressure and strain measurement.	2
18	Use electronic pressure & strain measurement in industrial system.	8
19	Identify & describe operation of various electronic timing application systems.	5
20	Use electronic timing systems in industrial applications.	10
21	Describe and demonstrate basic principles of telemetry.	4
22	Identify and demonstrate remote and multiplex data transmission.	2
23	Use voltage to freq. and freq. to voltage conversion system.	10
24	Use digital to analog and analog to digital conv. in industrial system.	10
25	Use logic to power interface for system operation.	12
26	Use 2 position & proportional controllers in industrial system.	12
27	Control industrial processes with direct digital control.	22
28	Diagnose/repair electronic control systems.	18
29	Operate typical robotic sensory systems.	14
30	Diagnose/repair typical industrial sensory systems.	35

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power Program: Robotics Technology
Manager: Jules Reed Course: Mechanisms/Drives/Linkages #5.2
1 Hours/Day for 12 Weeks Page 1 of 1
Total Course 60 Hours Prep. by: Craig Froke 12/15/82

	Skills:	Hours
01	Identify basic principles of force/motion.	1
02	Describe principles of work/energy.	1
03	Describe operation of simple and compound machines	1
04	Select proper fasteners for specific applications.	3
05	Identify principles of friction.	1
06	Select and use various industrial lubricants.	4
07	Install/inspect/maintain journal & frictionless bearings.	7
08	Describe applications of common/special couplings.	3
09	Identify types & applications of industrial clutches.	2
10	Identify types & applications of belt drives.	3
11	Identify types & applications of speed reducers.	3
12	Identify types & applications of gears.	4
13	Assemble gears to transmit motion.	5
14	Identify types & characteristics of linkage systems.	2
15	Assemble levers/linkages/gears for specific applications.	10
16	Test/troubleshoot mechanical systems.	10

Minneapolis Technical Institute

Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
1 Hour/Day for 12 Weeks
Total Course 60 Hours

Program: Robotics Technology
Course: Robotics Programming #5.3
Page 1 of 1
Prep. by: Craig Froke 11/0482

	Skills:	Hours
01	Write and explain ladder logic diagram.	10
02	Convert ladder diagram into written robot controller program.	10
03	Describe program/edit/monitor procedures for programmable controller.	15
04	Program a robot programmable controller.	25

Minneapolis Technical Institute
Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
Hours/Day for Weeks
Total Course 360 Hours

Program: Robotics Technology
Course: Electro-Mechanical Systems #6.1
Page 1 of 1
Prep. by: Craig Froke 12/15/82

	Skills:	Hours
01	Demonstrate operation of solenoid control valves.	3
02	Demonstrate operation of limit switches.	3
03	Demonstrate 1 cycle electro-hydraulic system.	4
04	Demonstrate automatic cycling electro-hydraulic system.	6
05	Demonstrate hydraulic sequencing with elect. control.	6
06	Determine torque & speed characteristics of D.C. motor.	5
07	Determine time constant of D.C. motor.	5
08	Connect, test, operate open loop positioning system.	8
09	Describe operation of hydraulic servo valve.	4
10	Demonstrate D.C. servomechanism principles.	6
11	Demonstrate velocity regulating servosystem.	10
12	Determine transient response of position servosystem.	15
13	Determine effects of inertia on position servosystem.	12
14	Demonstrate tachometer stabilization in position servosystem.	10
15	Demonstrate lead network stabilization in position servo.	10
16	Demonstrate open loop control of linear actuator.	12
17	Calibrate "span" adjustment of LVDT driven displ. indicator.	14
18	Demonstrate closed loop control of linear hyd. actuator.	12
19	Demonstrate open loop control of rotary hyd. motor.	12
20	Demonstrate closed loop rot. velocity control w/integ. amp.	14
21	Demonstrate closed loop pos. servo using rot. hyd. motor.	14
22	Demonstrate speed reg. & slip in angular vel. servosystem.	12
23	Digitally control number of shaft revolution.	10
24	Demonstrate digital command of velocity servo.	15
25	Demonstrate digital command of position servo.	15
26	Convert analog data into digital form.	12
27	Convert shaft position to digital value w/gray code wheel.	12
28	Demonstrate pos. servosystem using digital shaft encoder/decoder.	10
29	Demonstrate pos. servo using digital feedback & comparator.	12
30	Operate/troubleshoot various ind. electro-mechanical systems.	37
31	Connect/test/operate industrial systems to perform typical tasks.	40

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed

Program: Robotics Technology
Course: Manufacturing Materials/Processes #6.2
Page 1 of 1

1 Hour/Day for 12 Weeks
Total Course 60 Hours

Prep. by: Craig Froke 12/15/82

	Skills:	Hours
01	Identify types & characteristics of ferrous metal.	2
02	Identify types & characteristics of nonferrous metal.	2
03	Identify types & characteristics of alloys.	2
04	Identify types & characteristics of plastics.	1
05	Describe common metallurgical processes.	3
06	Describe typical industrial foundry processes.	2
07	Describe "special" casting processes.	2
08	Identify processes in cold working metal.	2
09	Identify processes of press forming metal.	2
10	Perform precision measurement.	5
11	Describe process of machining using turning machines.	2
12	Describe process of machining using shaper, planer.	2
13	Describe process of machining using millins machine.	2
14	Describe process of sawing & filing.	2
15	Describe process of broaching.	2
16	Describe process of grinding.	2
17	Describe screw thread manufacturing process.	1
18	Describe gear manufacturing process.	2
19	Describe powder metallurgy process.	1
20	Identify process of material polishing & finishing.	2
21	Identify "recent" processing techniques (chemical, laser, E.D.M. & etc.).	2
22	Describe CNC machining process.	3
23	Identify welding manufacturing processes.	2
24	Identify manufacturing safety standards.	2
25	Identify practices/standards for design/control of machinery.	5
26	Describe function of manufacturing.	3
27	Describe automated manufacturing of the future.	2

Minneapolis Technical Institute
Performance Profile Worksheet

Cluster: Energy & Power
Manager: Jules Reed
Hours/Day for Weeks
Total Course 240 Hours

Program: Robotics PGM
Course: Microprocessors/Programmable Controllers #7.1
Page 1 of 1
Prep. by: Craig Froke 04/29/83

Skills: **Hours**

01 Define microprocessor terms.
02 Describe purpose of microprocessor circuits.
03 Trace flow of data with block diagram.
04 Develop flow charts.
05 Write simple programs and run.
06 Describe architecture of typical microprocessor.
07 Explain operation instructions of microprocessor.
08 Write programs which use stack.
09 Write programs using subroutines.
10 Describe microprocessor interrupt.
11 Interface microprocessor with memory circuits.
12 Implement microprocessor interrupt.
13 Synchronize microprocessor with external timing signal.
14 Decode binary bit patterns.
15 Interface microprocessor to external data display.
16 Program microprocessor to accept externally applied data.
17 Use peripheral interface adapter (P.I.A.).
18 Interface microprocessor with transducer.
19 Use P.I.S. as I/O device for parallel to serial conv.
20 Interface D to A and A to D with microprocessor.
21 Id. operation of programmable controllers.
22 Program series/parallel/series-parallel networks on P.C.
23 Edit programmable controller program.
24 Program MCR and jump instructions on P.C.
25 Program timers and counters on P.C.
26 Program drum timers on P.C.
27 Troubleshoot and repair program controller.

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power Program: Robotics Technology
Manager: Jules Reed Course: Stepper Motor Robots #7.2
Hours/Day for Weeks Page 1 of 1
Total Course 120 Hours Prep. by: Craig Froke 12/15/82

	Skills:	Hours
01	Identify parts & operation of stepper motor robots.	10
02	Describe industrial applications of stepper motor robots.	10
03	Demonstrate operation of stepper motor robot.	10
04	Program stepper motor robot.	20
05	Write programs & test stepper motor robots for industrial applications.	70

Minneapolis Technical Institute — Performance Profile Worksheet

Cluster: Energy & Power	Program: Robotics Technology	
Manager: Jules Reed	Course: Robotic Applications	#8.1
Hours/Day for Weeks	Page 1 of 1	
Total Course 180 Hours	Prep. by: Craig Froke	12/15/82

	Skills:	**Hours**
01	Identify guidelines used to examine industrial robot applications.	5
02	Design, build & program robots to solve typical industrial problems.	175

2.01 Material Handling
2.02 Machine Loading
2.03 Die Casting
2.04 Mold Making
2.05 Press Loading
2.06 Forging/Heat Treating
2.07 Foundry
2.08 Welding
2.09 Machining
2.10 Finishing
2.11 Inspection
2.12 Assembly

Minneapolis Technical Institute Performance Profile Worksheet

Cluster: Energy & Power Program: Robotics Technology
Manager: Jules Reed Course: Industrial Robot Applications
Hours/Day for Weeks Page 1 of 1 #8.2
Total Course 180 Hours Prep. by: Craig Froke 12/15/82

Description: Industrial applications of robots in actual work situations will be examined. The course is delivered through an internship in an actual industrial setting. Major content areas of the internship include: Design, Research and Development of Robotic Installations along with the Installation, Safety Precautions, Programming, Troubleshooting and Maintenance of Robots. End of Arm Tooling and Gripper Applications are integral components of this course.

ROBOTICS TECHNICIAN PROGRAM PROPOSAL

APPENDIX B

OUTLINES OF COURSES OFFERED BY MINNEAPOLIS COMMUNITY COLLEGE

Course Title: Applied Algebra 1
Department from which course will be offered: Mathematics
Course Number: 106
Hours per week in lecture: 0
Hours per week in lab: 5
Credits: 5
General education requirement grouping satisfied:
Group C. Math/Science/Computer Science

Catalog Description of Course

For students beginning the study of algebra or for students that need a review of algebra that starts from the beginning. Course content includes: Solving non-fractional and fractional equations with signed numbers, solving systems of equations, graphing, working with scientific and technical formulas. Intermediate Algebra is a continuation of Elementary Algebra.

Prerequisite/Corequisite

Knowledge of arithmetic.

For Whom Intended

This course is part of the math learning lab series, Arithmetic, Elementary Algebra, and Trigonometry which prepares a student with high school math deficiencies for a pre-calculus course.

Objectives

The student shall be able to:

1) Solve equations in one unknown, non-fractional and fractional, with integers and rational numbers.
2) Graph linear and curvilinear equations using tables of values for the variables.
3) Rearrange scientific and technical formulas.
4) Solve systems of two equations using the graphical method, equivalence method, and the substitution method.

Topical Outline

1. Signed numbers
2. Non-fractional equations
3. Multiplication & division of fractions
4. Addition & subtraction of fractions
5. Fractional equations
6. Literal fractions
7. Graphing
8. Formula rearrangement
9. Systems of equations & formula derivation

General Instructional Method

Programmed materials with testing and tutoring in the Mathematics Learning Lab.

Applied Algebra 1 (continued)

Evaluation/Testing

Quarter grade is determined by chapter tests (75%) and a final exam (25%).

Instructional Media

Text: Basic Algebra by McHale and Witzke, Addison Wesley

Course Title: Applied Algebra 2
Department from which course will be offered: Math
Course Number: 109
Hours per week in lecture and discussion: 5
Credits: 5
General education requirement grouping satisfied:
Group C. Math/Science/Computer Science

Catalog Description of Course

This is a continuation of Elementary Algebra. Course content includes: square root radicals, quadratic equations and formulas, exponents and radicals, linear graphs and slope, logarithms and exponentials.

Prerequisite/Corequisite

Math 106

For Whom Intended

This course is part of the math learning lab series, Arithmetic, Elementary Algebra, Intermediate Algebra, and Trigonometry, which prepares a student with high school math deficiencies for a pre-calculus course.

Objectives

The student shall be able to:

1) Work with square root radicals - add, subtract, multiply and divide, rationalize demonimators.
2) Solve equations and rearrange formulas containing squares and square root radicals.
3) Solve quadratic equations and formulas.
4) Graph linear equations using slopes and intercepts.
5) Work with common and natural logarithms.
6) Solve equations and rearrange formulas containing logarithms and exponentials.

Topical Outline

1. Square & square root radicals
2. Equations with radicals
3. Quadratic equations
4. Exponents and radicals
5. Linear Graphs and slopes
6. Common and natural logs
7. Logarithms & exponentials : Laws & formulas

General Instructional Method

Programmed materials with testing and tutoring in the mathematics learning lab.

Applied Algebra 2 (continued)

Evaluation/Testing

Quarter grade will be determined by chapter tests (75%) & a final exam (25%).

Course Title: Intermediate Algebra and Trigonometry II
Department from which course will be offered: Math
Course Number: 110
Hours per week in lecture and discussion: 5
Hours in lab: 0
Credits: 5
General education requirement grouping satisfied:
Group C

Catalog Description

This course provides a continuation of the algebraic content of Intermediate Algebra together with an introduction to Trigonometry. Topics will include polynomials, algebraic functions, exponents and radicals, analysis of verbal problems, introduction to functions, angles, trigonometric functions of angles, solution of triangles.

Prerequisite/Corequisite

Math 109

For Whom Intended

Students intending to study mathematics, science, business or any other subject with mathematics content.

Objectives

1) Add, subtract, multiply, divide, and factor polynomials
2) Add, subtract, multiply, divide, algebraic fractions
3) Solve verbal problems
4) Use correctly the vocabulary of functions
5) Compute trigonometric functions via algebra, tables, and calculators
6) Solve right triangles

Topical Outline

1. Review of elementary algebra
2. Factoring
3. Algebraic fractions
4. Long division of polynomials
5. Solution of equations
6. Verbal problems
7. Intro to functions
8. Trigonometry

General Instructional Method

Lecture and problem solving

Evaluation/Testing

Weekly or bi-weekly tests; 3 hour final exam

Course Title: Introduction to Physics
Department from which course will be offered: Physics
Course Number: 100
Hours per week in lecture and discussion: 4
Hours per week in lab: 0 (Lab is Optional)
Credits: 4
General education requirement grouping satisfied:
C. Physical and Biological Sciences

Catalog Description

This course will acquaint the student with the physics that surround him in his everyday environment.* Computation is not emphasized. The course is designed primarily for the liberal arts student who needs a lab science course.

Prerequisite/Corequisite

Basic Algebra (Math 20) or the equivalent

For Whom Intended

Liberal arts majors desiring a lab science

Objectives

1) To provide the student with a greater awareness of physical reality.
2) To enable the student to understand and explain physical concepts related to this environment.
3) To give the student a greater appreciation for the scientific method so that he can make critical judgments of new concepts.
4) To present the physics of certain environment related issues to give the student a basis on which to evaluate those situation.

Topical Outline

Mechanics, properties of matter, heat, sound, electricity and magnetism, light and quantum theory, nuclear physics

General Instructional Method

Lectures, discussions, demonstrations, lab experiments

Evaluation/Testing

Completion of assignments, quizzes and final exam

Instructional Media

Test: *Conceptual Physics* by Paul Hewitt

*Topics which may be discussed include: colors from oil slicks, sailboats, automobiles, voltage, nuclear power plants

Course Title: College Physics 1 and 2
Department form which course will be offered: Physics
Course number: 131 and 132
Hours per week in lecture and discussion: 4
Hours per week in lab: 2
Credits: 5
General education requirement grouping satisfied:
Group C. Math/Science/Computer Science

Catalog Description

These courses are non-calculus based courses designed to help the student understand the behavior of physical phenomena which occur in his/her world. The courses satisfy physics requirements for certain science related programs such as pharmacy and architecture. The courses must be taken in sequence unless permission from the instructor is obtained.

Prerequisite/Corequisite

Two years of high school algebra with trigonometry or Math 106 and Math 109 or college algebra (Math 111) and college trigonometry (Math 112).

For Whom Intended

Principally: Pharmacy and architecture majors. Some other science related fields. Engineering students who need physics before taking engineering physics.

Objectives

To solve problems using the laws and principles of physics.

Topical Outline

Physics 131:

1. Vectors
2. Equilibrium of particles
3. Equilibrium of rigid bodies - Torque
4. Uniformly accelerated motion in one direction
5. Dynamics
6. Gravitation
7. Two dimensional motion
8. Work
9. Energy
10. Momentum
11. Fluids
12. Temperature Ideal Gas Law
13. Thermal properties of matter

College Physics 1 and 2 (continued)

Topical Outline (continued)

Physics 132:
1. Simple Harmonic motion
2. Waves
3. Sound
4. Electrostatics
5. Circuits (D.C.)
6. Magnetism
7. Electromechanical devices
8. Electromechanical waves
9. Geometrical optics
10. Physical optics
11. Atomic structure
12. Radiation

General Instruction Method

Lecture, demonstration, problem solving

Evaluation

Written exams on groups of chapters and final exam

Instructional Media

Text, lab, computer, slide rule or calculator

Equipment

Small generic equipment was purchased, but generally there is a reliance on area industry for training sites. There are two robot manufacturers in the area, MTS Systems and GCA/Par. Their staff and facilities are used to train students. Microprocessors and programmable controllers are accessible from other area companies such as Allen Bradley. Several area companies who use robots extensivley have volunteered to have classes at their sites. Those companies include Honeywell, 3M, Ford, Control Data, and Donaldson.

A list of equipment that was purchased for the first year and a list of equipment anticipated for the second year follow.

EQUIPMENT NEEDED FOR FIRST YEAR OF OPERATION

Qty.	Description	Unit Price	Total Price
	Upgrade and Expand Existing ASCI Microprocessors to Provide Robotic Control and Interface.		
3	Upgrade 16K Memory Boards to 32K with 8K Basic.	300.	900.
2	Upgrade 4K Memory Boards to 32K with 8K Basic.	1,430.	2,860.
2	ASCI "PDC" Peripheral Device Controller.	110.	220.
4	Universal Input/Output Controllers.	1,600.	6,400.
5	Automated Robot Transfer Line.	3,500.	17,500.
4	Programmable Controller Simulator.	995.	3,980.
1	EPR3 Single Arm Slide Robot	12,000.	12,000.
	To Include: SAK-3 Robot Kit EPC-31 PC Trainer with P.C. User's Manual		
		First Year Total=	$43,860.

EQUIPMENT NEEDED FOR SECOND YEAR OF OPERATION

Qty.	Description	Unit Price	Total Price
3	DP 130 Linkage Trainer	300.	900.
3	DP 150 Precision Mechanical Drive	1,400.	4,200.
1	EPR7 Double Arm Slide Robot	18,000.	18,000.
	To Include: DAK-6 Robot Kit EPC-32 PC520 Trainer EP-500 Video Terminal		
1	EPR10 Box Arm Slide Robot	32,000.	32,000.
	To Include: BAK-9 Robot Kit EPC-35 Computer w/CRT w/16 I/O Outputs w/32 L/O Outputs		

Second Year Total=$55,100.

Grand Total=$98,960.

Faculty

Faculty are generally employees of a Minnesota industries and are ad hoc. In fact, the core of the faculty are industry personnel. One person was hired for the program. Existing courses in electronics and computer science, and their respective faculties are also part of the program. Because the emphasis is on individualized upgrading and training during the night program, staff and faculty requirements are different from those of more traditional program.

PROGRAM: Material Handling/Robotics
INSTITUTION: Waukesha County Technical Institute
800 Main Street
Pewaukee, Wisconsin 53072
(414)548-5566
CONTACT PERSON: William L. Meier or Don Krummel
DEGREE: One-Year Vocational Diploma
(2 semesters, 31 credits)
DATE BEGAN: Fall 1982

History

This program was originally part of the material handling program, a 36-week course. In 1981, the advisory commitee conducted a study to determine if area employers would be interested in adding a robotics component to that program. It was found that employers were interested in hiring individuals with skills in robotics so a unit was added to the program in the Fall of 1982. At first, a six week block was added to the program which was dedicated to the study of industrial robots.

As new members were added to the advisory committee that were more inolved in making and using industrial robots, the recommendation became stronger to devote more time to the robotics component of the program.

As the program exists now, it is a 36 week program. Robotics and Material Handling are still part of the same degree program.

Advisory Committee

As noted above, the advisory committee has taken an active role in initiating a robotics-oriented degree as part of the material handling program. Representation on that committee includes forklift companies, conveying systems, and other industry representatives who make and use industrial robots or automated storage and retrieval systems.

The Program

The program is a 36-week (2 semester) program consisting of 31 credits. Courses are not offered at night as part of the degree program. However, non-credit robotics courses are offered in the evening such as Introduction to Robotics and Robot Programming. There are currently 14 full-time day students in the program. There are 30-36 students enrolled in the evening program.

The program is an individualized competency based program. One hour per week is spent in formal lectures and 24 hours per week are spent in the labs. Each person must spend a certain period of time studying electronics, math, and mechanical maintenance.

A profile of the program and course descriptions follows.

MATERIAL HANDLING EQUIPMENT/ROBOTICS REPAIR

A One-year Vocational Diploma Program

First Semester

Course	Hrs/Wk	Cr
Material Handling Equipment/Robotics Repair (36 wk)	24	12
Industrial Hydraulics	2	1
Industrial Math	3	2
Totals	29	15

Second Semester

Course	Hrs/Wk	Cr
Material Handling Equipment/Robotics Repair	24	12
Pneumatics	4	2
Industrial Communication	3	2
Totals	31	16

COURSE DESCRIPTION

Material Handling Equipment/Robotics (462-301)

This course is designed to provide the skills and knowledge necessary to repair and maintain material handling/robotics equipment which is used to move, locate, store, etc., various equipment and materials. The student will learn how to diagnose and repair internal combustion engines, electric motors, and pneumatic hydraulic components. Hands-on activities will include the removal, tear-down, re-assembly, and installation of material handling/robotics components. The course will also include safety procedures; the use of manuals, hand tools, and power tools; basic electricity and welding, including primary schematic and blueprint reading skills; and preventive maintenance and trouble-shooting procedures.

Industrial Hydraulics (420-302)

This introductory, individualized course is designed to give the student a practical background in hydraulically-powered machines and work-saving devices, as they apply to industrial and mobile systems. Particular emphasis is placed on the various components and their relation to the total circuit operation of the machines.

Industrial Math (804-320)

Topics of applied arithmetic, applied algebra, and applied geometry are presented in an individualized course.

Pneumatics (420-320)

This course includes a study of the components used in pneumatic and pneumatic-hydraulic circuitry. Design, selection, and application criteria for air compressors, valves, cylinders, boosters and related devices will be evaluated. The application of these components to industrial circuitry used on machine tool, material handling, and jig and fixture tooling is stressed.

Industrial Communication (801-311)

Learning experiences are designed to expand the student's level of awareness and skill in interpersonal communication, both oral and written, with emphasis on securing and maintaining a job.

Course Title: Material Handling Equip./Robotics Repair
Course Number: 462-301
Course Value: 24 Credits

This course is designed to provide the skills and knowledge necessary to repair and maintain material handling/robotics equipment which is used to move, locate, store, etc., various equipment and materials. The student will learn how to diagnose and repair internal combustion engines, electric motors, and pneumatic hydraulic components. Hands-on activities will include the removal, tear-down, re-assembly, and installation of material handling/robotics components. The course will also include safety procedures; the use of manuals, hand tools, and power tools; basic electricity and welding, including primary schematic and blue-print reading skills; and preventive maintenance and troubleshooting procedures.

I. Shop Orientation

  A. Shop Safety and Driver Training
  B. Shop Procedures
  C. Hand and Power Tools
  D. Parts and Maintenance Manuals
  E. Fasteners and Fittings
  F. Product Identification
  G. Workmanship and Quality
  H. Basic Blueprint Reading
  I. Maintenance Management

II. Electricity

A. AC-DC Theory
B. Reading Electrical Schematics
C. Battery Construction, Charging, and Testing
D. Test Instruments
E. Electric Motors
F. Switches and Solenoids
G. SCR Controls
H. Troubling Shooting Electriclal Circuits and Wiring
I. Other Control Systems

III. Welding

A. Welding Set Up
B. Oxuacetylene Cutting
C. Oxyacetylene Cutting
D. Brazing
E. Arc Welding

IV. Internal Combustion Engines

A. Engine Theory
B. Electrical Systems
C. Fuel Systems
D. Engine Troubleshooting

V. Drive Line

A. Transmissions
B. Differentials
C. Clutches
D. Hysrostatic
E. Steering
F. Brakes
G. Tires and Wheels
H. Lubricants and Applications

VI. Hydraulic and Pneumatics

A. Inspections in Safety
B. Masts, Forks, and Capacity Ratings
C. Chains and Sprockets
D. Hydraulic/Pneumatic Component Repair
E. Attachments
F. Hoses and Fittings

VII. Cranes, Hoists, and Lifts

A. Manual
B. Electric
C. Hydraulic
D. Pneumatic

VIII. Robotics

- A. Types and Applications
- B. Schematics
- C. Drives
- D. Linkages
- E. Functions
- F. Mobility

MATERIAL HANDLING EQUIPMENT/ROBOTICS REPAIR

OBJECTIVE: Upon completion of this unit, the student will be able to assemble, install and maintain the electrical, mechanical, pneumatic, and hydraulic components on computer-assisted multi-purpose equipment.

OUTLINE:

I. Introduction to Robotics
- A. Types
- B. Applications
- C. Programming
- D. Functions

II. Diagram and Print Reading

- A. Installations and Specifications
- B. Blueprints
- C. Wiring Diagrams
  - 1. Power Supply
  - 2. Controllers
  - 3. Robot

III. Drives

- A. Mechanical

  - 1. Gear
  - 2. Belt & Pulley
  - 3. Chain & Sprocket

- B. Electrical
- C. Hydraulic

IV. Linkages

- A. Types
- B. Applications
- C. Repair

V. Controllers

   A. Programming
   B. Troubleshooting
   C. Servicing

VI. Robots

   A. Operation
   B. Troubleshooting
   C. Servicing

Course Title: Material Handling/Robotics
Course Number: 462-301
Course Value: 12 Credits

COURSE OUTCOME STATEMENTS (OBJECTIVES/COMPETENCIES):

Upon completion of this course the student will be able to:

1. Identify basic power tools.
2. Demonstrate proper operation of power tools.
3. Demonstrate proper care and maintenance of power tools.
4. Demonstrate proper use of manufacturer's literature.
5. Exhibit proper working habits.
6. Use a parts manual to order new parts for material handling equipment
7. Use a maintenance manual as a guide to repair.
8. Identify various fasteners and fittings.
9. Select the proper fastener for a given job and install it.
10. Understand product identification.
11. Read hydraulic schematics for Material Handling/ Robotics equipment.
12. Read electrical schematics for Material Handling/ Robotics equipment.
13. Demonstrate correct behavior in a shop maintenance situation
14. Describe basic AC-DC theory.
15. Use electrical schematics in trouble-shooting Material Handling/Robotics equipment.
16. Describe how a battery is constructed.
17. Demonstrate the proper method of changing batteries.
18. Demonstrate the proper use of electrical test equipment.
19. Describe electric motor operation.
20. Identify switches and solenoids.
21. Describe how switches and solenoids work.
22. Describe SCR controls.
23. Demonstrate proper methods of trouble-shooting electrical circuits and wiring.

24. Demonstrate proper method of setting up an arc welder.
25. Demonstrate proper arc welding methods.
26. Demonstrate proper method of setting up oxyacetylene welding equipment.
27. Demonstrate proper gas welding methods.
28. Demonstrate proper braze welding methods.
29. Demonstrate proper method of setting up oxyacetylene cutting.
30. Describe the operation of the internal combustion engine.
31. Describe the internal combustion engine electrical system operation.
32. Demonstrate the proper method of trouble-shooting internal combustion engine electrical problems.
33. Demonstrate proper internal combustion engine maintenance.
34. Demonstrate proper method of trouble-shooting mechanical problems of the internal combustion engine.
35. Describe transmission operation.
36. Perform basic transmission maintenance.
37. Describe differential operation.
38. Describe clutch operation.
39. Identify various types of clutches.
40. Describe hydrostatic transmission operation.
41. Describe steering operation.
42. Describe brake systems.
43. Trouble-shoot brake systems.
44. Install and remove tires and wheels.
45. Identify various lubricants and their applications.
46. Use lubricant properly.
47. Demonstrate proper methods of inspecting Material Handling/Robotics equipment.
48. Describe mast and fork operation.
49. Describe chain and sprocket operation.
50. Demonstrate proper chain and sprocket installation methods.
51. Perform simple hydraulic/pneumatic component repair.
52. Identify various equipment attachments.
53. Properly install/disconnect various equipment attachments.
54. Describe manual crane, hoist and lift operation.
55. Describe electric crane, hoist and lift operation.
56. Describe pneumatic crane, hoist and lift operation.
57. Describe hydraulic crane, hoist and lift operation.
58. Identify various types of robots and their applications.
59. Describe electrical, hydraulic pneumatic schematics as they apply to industrial robots.
60. Describe robot drive system operation.
61. Describe operation of various types of industrial robots.
62. Describe mobility of an industrial robot.
63. Operate industrial robots properly.
64. Trouble-shoot and maintain industrial robots properly.

Equipment

The program utilizes a Clark High Lift Stacker, A Yale 4000 lb. electric fork lift, three Prab Model 5200 industrial robots, a GMF Model S-1R industrial robot, a GMF Model M-00 industrial robot, a microbot, a Rhino robot, a belt conveyor, and a workpiece feeder conveyor which is directly interfaced to the GMF M-00 robot. Presently, the total curriculum is being rewritten to add more digital electronics and industrial robot competencies.

Faculty

One staff person was hired to develop and teach the robotics courses. His background is in maintenance mechanics and engineering. He has also taken courses at General Motors-Fanick in Michigan for upgrading and training in the current industrial uses of robots.

Placement

One class has completed the program as of this writing. Eleven individuals were enrolled in the program and four completed their diploma on time. Many of the enrollees had funding problems midway through the program and had to drop out. Those four graduates are currectly working in jobs related to their training.

The Future

It is expected that the program will be modified in the near future. More computer skills will be introduced into the curriculum. It is also possible that the program might be extended to a two-year Associate Degree program.

PROGRAM: Robotics Technology - An Option Program
in Electronics Technology
INSTITUTION: Vincennes University
1002 North First Street
Vincennes IN 47591
(812) 882-3350
CONTACT PERSON: Dean Bill G. Spence
DEGREE: Associate of Science Degree (two years)
DATE BEGAN: 1983

History

Vincennes University includes both Academic transfer programs and Occupational Education programs which prepare students for entry into jobs at the end of two years. The Technology Division is one of four divisions in the Occupational Education Area. The Electronics Technology Department had consisted of two programs - Electronics and Laser/Electro-Optics Technology. The Robotics Program was introduced as a third option within the Electronics Department. Several of the same courses were required for all three options. The Communications areas of the current Electronics Program was dropped for Robotics Program requirements. Five new robotics courses totalling 16 semester hours were developed to replace those courses.

Advisory Committee

The advisory committee was instrumental in directing the development of these five new courses. It includes representatives from the following industries and societies:

Thermwood Corporation
Cybotech Corporation
Hoover Universal - Automotive Products Division
E. E. Equipment Co. - Division of C. M. Buck and Associates
Cincinnati Milacron - Industrial Robot Division
Advanced Robotics Corporation
The DeVilbiss Company
Seiko Instrument, USA
Prab Robots, Incorporated
Society of Manufacturing Engineers - Robotics Div.
GM Technical Center
Allen-Bradley
Steelweld Robotics Corporation

The Program

The curriculum will prepare graduates to enter the robotics field or many phases of automated manufacturing as service technicians, engineering assistants, manufacturing and industrial maintenance technicians. Students gain additional laboratory experiences in electronic fundamentals, communication techniques, digital systems and micro-processors.

FIRST YEAR

		SEM I	SEM II
TEL 110	DC and AC Circuit Analysis	5	
TEL 125	Transistor Circuit Design	4	
SMA 102	College Algebra	3	
HEW 101	English Composition I	3	
SMA 104	Trigonometry		3
TRO 150	Introduction To Robotics		3
SNT 160	The Physics of Hydraulics & Pneumatics		3
TEL 170	Digital Systems and Computer Circuitry		5
SNT 150	Computer Programming for Electronics		3
	Total	15	17

SECOND YEAR

TRO 200	Robotics Interfacing	5	
TRO 210	Hydraulics & Pneumatics Control	3	
TEL 200	Microprocessor Hardware	3	
TEL 230	Microprocessor Software & Interfacing	3	
	Social Science Elective	3	
	Physical Education Activity		1
TRO 250	Robotics Applications and Servicing		4
TEL 255	Industrial Electronics Control		3
	Approved Humanities Elective		3
	Social Science Elective		3
	Physical Education Activity		1
	Total	17	15

Emphasis is on "doing". The lab/lecture ratio is about 2:1. Laboratory experiences contribute heavily with 25-30 weekly hours of classroom experience. Students gain laboratory experience in electronics fundamentals, digital systems, microprocessors, hydraulic/pneumatic systems and robot systems.

Students with a Math S.A.T. score of less than 450 might have difficulty completing the program in four semesters.

The courses added for the Robotics Option are described below. Also included are course descriptions of the Electronics courses.

(TENTATIVE)

TRO-150

INTRODUCTION TO ROBOTICS
(Labs)

1. Operation of the Apple II Computer
   (Basic & Assembly Language)
2. Interfacing the Apple & Rhino
   Rhino Keyboard Move Operation
3. Rhino Teach Program
4. Rhino Move All Joints Program
5. Thino X, Y, Z, Program
6. Servo Motors (Rhino Servo Motors Driven by Apple
   Assembly Language and Parallel Interface Card)
7. Rhino Mechanical Servicing
   Servicing Rhino Controller
8. Rhino Software Development
9. Rhino Applications Programs
10. Stepping Motors (Microbot Steppers Driven by Apple
    Assembly Language and Parallel Interface Card)
11. Microbot Robot Interfacing
12. Microbot Applications
13. Heath Hero I: Operation
14. Heath Hero I: Programming
15. Introduction to Programming Industrial Robots
    A. Motion Mate (Non-Servo Point-to-Point
    B. Thermwood (Lead Through Teach)
    C. Seiko (Non-Servo Point-to-Point with A/B Prog.
       Controller)
    D. T^3 Electric
    E. Cartisian Coordinate - Thermwood #20

TEL-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

Operation of the Apple Computer

LECTURE 1

I. ORIENTATION

1. Assign seats, benches, lockers, etc.
2. Syllabus and lab manual
3. Grading policies & other regulations

II. INDUSTRIAL ROBOTS TODAY

1. Slides of Robotics VI Expo.
2. About Robots (Sec. 6)

III. RHINO MANUAL

1. Credits (Sec. 1)
2. Special Instructions (Sec. 2)
3. Ordering Information (Sec. 3)
4. Things Not To Do
5. Do These Things (Sec. 5)
6. How The XR-1 Was Born (Sec. 7)
7. What Comes With The Rhino (Sec. 9)

IV. RHINO/APPLE ROBOT TEACHING SYSTEM

1. Apple II plus computer
2. Apple Disc
3. Programs
   - A. Introduction to Keyboard
   - B. D.O.S. 3.3 System Master
   - C. Apple Manuals
4. Rhino/Apple Demonstration

LAB: PERFORMANCE BASED TRA

1-A: The student will Operate an Apple Computer.

Performance will be satisfactory if student can:

1. Run "Intro to the Keyboard" floppy disc program.
2. Play a game.

1-B: The student will Copy a Floppy Disc.

1. Interface floppy disc.
2. Copy the Rhino Rasp #1-A demo disc tape and run it.
3. Copy floppy using only one disc.

1-C: The student will Program the Apple in Applesoft.

Performance will be satisfactory if program is written by student.

TEL-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 2

I. INTERFACING RHINO TO CONTROLLER

1. Getting Started (Sec. 18)
    - A. Shipping
    - B. Unfolding the Rhino
    - C. Power Supply Check Out
    - D. Motor Connections
    - E. Motor Test
2. Resetting the Rhino (Sec. 17)

II. THE RHINO CONTROLLER THEORY

1. Schematic
2. Rhino Design Parameters (Sec. 8)
3. Operation of the Intel 8748 (Sec. 13)
4. Rhino Component Descriptions (Sec. 10)

III. INTERFACING RHINO & CONTROLLER TO APPLE

1. RS232 Standards (Sec. 31)
2. Apple RS232 Specs & Cable Connector

IV. RHINO ACCESSORIES

1. Carousel, Conveyer, Slide base (Sec. 12)
2. Power Supply (Sec. 23)
3. Slide Base (Sec. 12A)
4. Conveyor (Sec. 12B)
5. Carousel (Sec. 12C)

LAB 2

2-A: The student will Test the Rhino.

Performance will be satisfactory if Self Test Program operates according with Sec. 18 of Rhino manual.

2-B: The student will Interface Rhino Controller.

Performance will be satisfactory if the student can:

1. Install Apple Super Serivla Card.
2. Connect controller to Apple via RS232.
3. Operate a motor with Rhino Rasp 1-A program.
4. Identify RS 232 connections.
5. Connect motors of Rhino properly to controller.

2-C. The student will Interface Transport Devices.

Performance will be satisfactory if Self Test Program operates according with Sec. 18 of Rhino manual.

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 2 (cont'd.)

3-A. CLASSIFICATION OF COMMERCIAL ROBOTS

1. Hydraulic
2. Pneumatic
3. Servo
4. Other

3-B. RHINO KEYBOARD MOVE PROGRAM

1. Practice for Motora A-F
2. Move Motors G & H

3-C. RHINO SERVO MOTOR THEORY

1. Motor Relationships & Data (Sec. 24)
2. Optical Encoders (Sec. 15)

LAB 2 (cont'd.)

3-A. The student will Operate a Rhino.

Performance will be satisfactory if student can:

1. Operate from Rhino Rasp #1-A keyboard control.
2. Operate similar to a pick and place sequence.

3-B. The student will Operate Rhino Transport Devices.

Performance will be satisfactory if student can operate:

1. Index table
2. Linear index table
3. X-Y table
4. Conveyer
5. Robot with transport devices

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 3	LAB 3
4-C. TEACH PROGRAMMING 1. Homing 2. Create 3. Modify 4. Save 5. Run 4-D. TEACH PROGRAMS FOR COMMERCIAL PROGRAMS 1. Pendants 2. Keyboard 3. Lead Through 4-B. VIDEOTAPES OF COMMERCIAL ROBOTS 1. Devilibus Tralpha 2. Cybotech Demo Tape 3. Cincinnati Milicron 4. Thermwood Demo Tape 4-A. APPLICATIONS OF COMMERCIAL ROBOTS 1. Welding 2. Painting 3. Assembly 4. Machine & Tool Loading 5. Palletizing	The student will "teach the robot" P.W.B.S.I. 4-A. Home the Robot. 4-B. Create a Move Sequence. 4-C. Modify a Move Sequence. 4-D. Save a Move Sequence. 4-E. Run a Move Sequence.

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 4

4-A. COMMERCIAL ROBOT OPERATION

1. Videotapes of Robotics IV Expo--Detroit 1982
2. Programmable Controllers for Hydraulic & Pneumatic Units

4-B. RHINO HANDS

1. Standard Hands (Sec. 11)
2. Deluxe Hands (Sec. 11-A)

4-C. RHINO MOVE ALL JOINTS PROGRAM

1. Servo motor steps
2. Lock-up
3. Computing Moves
4. Editing Moves
5. Point-to-Point Moves

LAB 4

4-A. The student will Move All Joints.

Performance will be satisfactory if:

1. No lock-up
2. Move to a point
3. Move six (6) robot motors

4-B. The student will Compute Moves.

Performance will be satisfactory if:

1. Moves to computed point
2. Moves all eight (8) motors

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 5

5-A. HOMING A ROBOT

1. Rhino Micro-Switches (Sec. 16)
2. Resetting the Rhino (Sec. 17)
3. Software Limit Protection

5-B. PICK & PLACE PROGRAMS

1. XYZ Coordinates
2. Point-to-Point Calculations

LAB 5

6-A. The student will Run an "XYZ" Program.

Performance will be satisfactory if:

1. Limit switches are installed and adjusted properly.
2. Rhino will zero.
3. The student will create a program.
4. The student will modify a program.
5. The student will save a program.
6. The student will run a program.

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 7

7-A. MECHANICAL SERVICING

1. Hardware Date (Sec. 22)
2. Maintenance (Sec. 27)
3. Parts List (Sec. 35)

7-B. PRECISION MEASUREMENTS

1. Micromotor

7-C. ADJUSTMENTS

1. Sec. 12A-3
2. Oil Sec. 12A-4, 12-B-4
3. Sec. 12B-3

LAB 7

7-A. The student will Replace a Mechanical Part.

Performance will be satisfactory if given part is replaced and unit performs normally afterwards.

7-B. The student will Replace Drive String.

Performance will be satisfactory if student replaces:

1. One belt
2. One chain
3. One cable

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 7 (cont'd.)	LAB 7 (cont'd.)
8-A. Electronic Servicing 1. Troubleshooting Hints (Sec. 28) 2. Electron Repair (Sec. 29)	8-A. The student will Isolate a Hardware Defect. Performance will be satisfactory if problem can be isolated to controller, host computer or power supply.
8-B. Theory of Controller 1. Sec. 10-3 (Controller Card) 2. Sec. 10-2 (Encloders) 3. Sec. 14 (Operation of the Controller) 4. Schematic	8-B. The student will Diagnose a Software Defect.

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 8	LAB 8
9-A. SOFTWARE THEORY 1. Software Consideration (Sec. 19) 2. Software Listings & Flow Diagrams (Sec. 21) 3. Firmware for 8748 (Sec. 25) 4. Further Firmware Possibilities (Sec. 26) 9-B. STUDY OF RHINO RASP 1-A 9-C. CREATE OWN SOFTWARE 1. Move all Joints 2. Teaching	9-A. The student will Write A Program to Move One Motor.

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 9	LAB 9
10-A. APPLICATIONS 1. Rhino Writer 2. Dremel Routing 3. Painting 4. Assembling	10-A. The student will Develop an Application Program. Performance will be satisfactory if the student: 1. Performs one of the applications listed.

TRO-150 COURSE CONTENTS: INTRODUCTION TO ROBOTICS

LECTURE 15-A

MOTION MATE ROBOT

1. General Description
2. Safety
3. Robot
4. Command Module
5. Motion Mate Adjustments
    a. Grippers
    b. Lift
    c. Retract
    d. Rotation
    e. Adjustable shock
    f. Wrist rotation
    g. Speed control adjustment
6. Installation
    a. Electrical
    b. Mounting
    c. Parts feeding
    d. Machine control
7. Set-Up
    a. Checklist

LAB 15-A

The student will Adjust Motion Mate Robot.

Performance will be satisfactory if student can adjust the following properly:

1. Grippers
2. Lift
3. Retract
4. Rotation
5. Adjustable Shock
6. Wrist Rotation
7. Speed Control Adjustment

The student will Install Motion Mate.

Performance will be satisfactory if the student can adjust the following properly:

1. Electrical
2. Mounting
3. Parts feeding
4. Machine control

The student will set up motion mate.

LECTURE 15-A (Cont'd.)

MOTION MATE ROBOT (Cont'd.)

1. Programming the Motion Mate
    - A. Mode A
    - B. Mode B
    - C. Example
    - D. Program running
    - E. Program creation
2. Maintenance
    - A. Lubrication
    - B. Controller
    - C. Cleaning
    - D. Troubleshooting charts
3. Theory
    - A. Wiring diagram
    - B. Circuit ladder diagrams
    - C. C.P.U. theory

LAB 15-A (Cont'd.)

The student will Initialize Motion Mate.

The student will Teach the Motion Mate.

Performance will be satisfactory if example is operational (pg. 7.5).

The student will create a teach program.

The student will troubleshoot down motion mate.

TEL 160 IC & DISCRETE LINEAR APPLICATIONS

VINCENNES UNIVERSITY
TECHNOLOGY DIVISION
ELECTRONICS DEPARTMENT

COURSE DESCRIPTION: The application of linear integrated circuits & design of operational amplifiers, oscillators, & other specialized circuits. Class work is based on discrete & non-discrete component operations with special emphasis on small & medium integrated circuit technology. Three hours lecture, five hours laboratory.

COURSE FOCUS: Emphasis is placed on linear op-amp and transistor circuits.

COURSE GOALS/ OBJECTIVES: The following goals will be addressed:
Performance Objectives matching & expanding these goals can be found in Addendum A.

1. Interpret op amp data
2. Design op amp amplifiers
3. Test op amp amplifiers
4. Define op amp offsets
5. Control op amp offsets
6. Test op amp offset control circuit
7. State op amp slew rate characteristics
8. Utilize op amp frequency compensation
9. Test op amp frequency compensation
10. Stipulate summing op amp characteristics
11. Design summing op amp circuits
12. Build summing op amp circuits
13. List op amp difference amplifier specs
14. Design op amp difference amplifiers
15. Test op amp difference amplifiers
16. Identify op amp waveshaping
17. Design op amp low pass filters
18. Design op amp high pass filters
19. Test op amp active filters
20. Design op amp wide bandpass amplifier
21. Test op amp wide bandpass amplifier
22. Design ramp generator
23. Design comparators
24. Test comparators
25. Test ramp generators
26. Test triangle generators
27. Design two-T oscillators
28. Test twin-T oscillators
29. Build wiring harness
30. Design regulated power supplies
31. Construct regulated supplies
32. Test power supply
33. State 555 timer characteristics
34. Control 555 timer
35. Test 555 timer circuits
36. Explain Schmitt trigger operation
37. Design Schmitt trigger
38. Test Schmitt trigger
39. Explain phase shift network operation.
40. Design phase shift oscillator
41. Test phase shift oscillator
42. Test crystal characteristics
43. Design crystal oscillator
44. Test crystal oscillator
45. List oscillator operation
46. Take final exam

COURSE REFERENCES: Text: Jefferson, Boyce C., *Operational Amplifiers for Technicians*, Breton Publishers, 1983 Edition

Manual: *IC & Discrete Linear Applications*, Vincennes University, 1983 Edition

cont'd.

TEL 160 IC & DISCRETE LINEAR APPLICATIONS (Cont'd.)

STUDENT EXPECTATIONS: To perform labs, take tests & construct power supply.

EVALUATION: The course has a total of 1000 points. Performance & grade translation will be made according to the following; 900 points for an A, 800 points for a B, 700 points for a C, and 600 points for a D. Points will be assigned according to Addendum B.

COURSE SCHEDULE: The course goals will be met at the average rate of 3 goals per week for 15 weeks (one semester).

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #1: Inverting & Non-Inverting Amplifiers

ADDENDUM A

LECTURE OUTLINE

I. BLACK BOX ANALYSIS

II. THE MONOLITHIC PROCESS

III. OPEN & CLOSED LOOP VOLTAGE GAIN

IV. SPECIFICATION SHEET ANALYSIS

V. COMMON MODE REJECTION RADIO (CMRR)

VI. INPUT BIAS CURRENTS

VII. POWER SUPPLY PROTECTION

VIII. POSITIVE & NEGATIVE FEEDBACK

IX. THE VOLTAGE FOLLOWER (BUFFER AMPLIFIER)

X. VOLTAGE AMPLIFICATION

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

1. Without reference, the student will interpret op amp data. Performance will be satisfactory if the student meets testing requirements.

2. Given necessary materials, the student will test op amp amplifiers. Performance will be satisfactory when criteria of the Op-Amp Handbook by Hughes are met.

3. Given required equipment & material, the student will test op amp amplifiers. Performance will be satisfactory if steps listed in Operational Amplifiers & Linear Integrated Circuits by Coughlin-Driscoll have been performed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #2: Offset Control

ADDENDUM A

LECTURE OUTLINE

I. BALANCING INPUT OFFSET CURRENTS

II. BALANCING INPUT OFFSET VOLTAGE

III. EXTERNAL OFFSET CONTROL

IV. INTERNAL OFFSET CONTROL

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

4. Given necessary materials, the student will define op amp offsets. Performance will be satisfactory if standards set by the Op-Amp Handbook by Hughes have been met.

5. Given necessary equipment & materials, the student will control op amp offsets. Performance will be satisfactory if all requirements of the IC lab manual have been met.

6. Given necessary equipment & material, the student will test op amp offset control circuits. Performance will be satisfactory if all requirements of the IC lab manual have been completed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #3: Unity Gain With Fast Response

ADDENDUM A

LECTURE OUTLINE

I. SLEW RATE

II. DECIBEL TERMINOLOGY

III. OPEN & CLOSED LOOP FREQUENCY RESPONSE

IV. ROLLOFF FREQUENCY COMPENSATION

V. EXTRENAL OSCILLATIONS & STABILITY CRITERIA

VI. THE BASIC PHASE COMPENSATION NETWORK

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

7. Given necessary materials, the student will state op amp slew rate characteristics. Performance will be satisfactory if the standards set by the Op-Amp Handbook by Hughes have met testing requirements.

8. Given necessary equipment & materials, the student will utilize op amp frequency compensation. Performance will be satisfactory if all requirements of the IC lab manual have been met.

9. Given necessary equipment & materials, the student will test op amp frequency compensation. Performance will be satisfactory if the steps listed in Operational Amplifiers & Linear Integrated Circuits by Coughlin-Driscoll have been performed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #4: Summing Amplifiers

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)
I. SUMMING AMP II. SCALING FACTORS III. SCALING AMPLIFIER APPLICATIONS (THE WEIGHTED SUMMING AMP)	10. Given necessary materials, the student will stipulate summing op amp characteristics. Performance will be satisfactory if the standards by the Op-Amp Handbook by Hughes are completed. 11. Given necessary materials, the student will design summing op amp circuits. Performance will be satisfactory if all criteria set by Op-Amp Handbook by Hughes are met. 12. Given necessary equipment & materials, the student will build summing op amp circuits. Performance will be satisfactory if all requirements of the IC lab manual have been completed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #5: Difference Amplifiers

ADDENDUM A

LECTURE OUTLINE

I. INPUT VOLTAGE REQUIREMENTS

II. INPUT BALANCING NETWORKS

III. SINGLE & DOUBLE ENDED OUTPUTS

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

13. Given necessary materials, the student will list op amp difference amplifier specs. Performance will be satisfactory if the standards in the Op Amp Handbook are met.

14. Given necessary materials, the student will design op amp difference amplifiers. Performance will be satisfactory if all criteria set by the Op Amp Handbook are met.

15. Given necessary equipment & materials, the student will test op amp difference amplifiers. Performance will be satisfactory if all the requirements listed in text by Coughlin-Driscoll have been met.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #6: Active Filters

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)
I. HIGH PASS (DIFFERENTIATOR) II. LOW PASS (INTEGRATION) III. THE BUTTERWORTH LOW PASS FILTER IV. THE BUTTERWORTH HIGH PASS FILTER	16. Given necessary materials, the student will identify op amp waveshaping. Performance will be satisfactory if the waveforms identified in Op Amp Handbook are drawn. 17. Given necessary materials, the student will design op amp low pass filters. Performance will be satisfactory if all criteria set by Op Amp Handbook are met. 18. Given necessary materials, the student will design op amp high pass filters. Performance will be satisfactory if all criteria listed by Op Amp Handbook are met. 19. Given necessary equipment & materials, the student will test op amp active filters. Performance will be satisfactory if all requirements of IC lab manual have been completed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #7: Wide Bandpass Amplifier

ADDENDUM A

LECTURE OUTLINE

I. AMPLIFIER CONSIDERATIONS

II. PASSBAND FREQUENCY SWITCHING NETWORKS

III. BANDPASS AMPLIFIER APPLICATIONS

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

20. Given necessary equipment, the student will design op amp wide bandpass amplifier. Performance will be satisfactory if all criteria set by Op Amp Handbook is met.

21. Given necessary equipment & materials, the student will test op amp wide bandpass amplifier. Performance will be satisfactory if all requirements of text are met.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #8: Triangle Generator

ADDENDUM A

LECTURE OUTLINE

I. BASIC RAMP GENERATOR

II. BASIC COMPARATORS

III. LOWER & UPPER THRESHOLD VOLTAGES

IV. COMPARATOR HYSTERESIS & VOLTAGE SENSING

V. COMPOUND OUTPUT WAVEFORMS OF THE TRIANGLE GENERATOR

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

22. Given necessary materials, the student will design ramp generator. Performance will be satisfactory if all criteria set by Op Amp Handbook has been met.

23. Given necessary materials, the student will design comparators. Performance will be satisfactory if all criteria listed by Op Amp Handbook is met.

24. Given necessary equipment & materials, the student will test comparators. Performance will be satisfactory if the requirements of the IC lab manual have been completed.

25. Given necessary equipment & materials, the student will test ramp generators. Performance will be satisfactory if the standards of the text have been met.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #9: TWIN-T OSCILLATOR

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)
I. PARALLEL T OSCILLATOR THEORY II. FEEDBACK RATIOS III. FREQUENCY STABILIZATION IV. AMPLITUDE STABILITY	27. Given necessary materials, the student will design twin-T oscillator. Performance will be satisfactory if criteria set by Op Amp Handbook has been met. 28. Given necessary equipment & materials, the student will test twin-T oscillators. Performance will be satisfactory if all requirements of the IC lab manual have been completed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #10: Power Supply Regulators

ADDENDUM A

LECTURE OUTLINE

I. ZENER DIODE THEORY & OPERATION

II. EXTENDING THE RANGE OF A ZENER

III. POSITIVE & NEGATIVE REGULATORS

IV. DUAL TRACKING REGULATORS

V. PROJECT: BI-POLAR REGULATION (± 20 VOLTS)

VI. PROJECT: DIGITAL REGULATION REQUIREMENTS

VII. PROJECT: TWO-WAY COMMUNICATION REGULATION REQUIREMENTS (+13.8 VOLTS)

VIII. PC BOARD CONSTRUCTION

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

29. Given necessary equipment & materials, the student will build wiring harness. Performance will be satisfactory if circuits meet text standards.

30. Given necessary materials, the student will design regulated power supplies. Performance will be satisfactory if all criteria set by Op Amp Handbook is met.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #11: Power Supply Construction & Testing

ADDENDUM A

LECTURE OUTLINE

I. CHASSIS CONSTRUCTION

II. WIRING OF CONTROLS TO PC BOARD

III. TESTING OF BI-POLAR & FIXED SUPPLIES

- A. Regulation
- B. Ripple

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

31. Given necessary equipment & materials, the student will construct regulated supplies. Performance will be satisfactory if the circuit meets text standards.

32. Given necessary equipment & materials, the student will test power supply. Performance will be satisfactory if the requirements in the text have been completed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #12: Timing Circuits

ADDENDUM A

LECTURE OUTLINE

I. INTRODUCTION TO THE 555 TIMER

II. CONTROL WITH RC TIME CONSTANTS

III. APPLICATIONS OF THE 555 TIMER

IV. THE BASIC TIMING CIRCUIT (THE MONOSTABLE)

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

33. Without reference, the student will state 555 timer characteristics. Performance will be satisfactory if student meets testing requirements.

34. Given necessary equipment & materials, the student will control 555 timer. Performance will be satisfactory if all requirements of the IC lab manual have been met.

35. Given necessary equipment & materials, the student will test 555 timer circuits. Performance will be satisfactory if steps listed in text have been performed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #13: Schmitt Trigger

ADDENDUM A

LECTURE OUTLINE

I. SCHMITT TRIGGER APPLICATIONS

II. HYSTERESIS ANALYSIS

III. DETERMINATION OF UTP & LTP

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

36. Without reference, the student will explain Schmitt trigger operation. Performance will be satisfactory if the student meets testing requirements.

37. Given necessary materials, the student will design Schmitt trigger. Performance will be satisfactory if all criteria set by Op Amp Handbook has been met.

38. Given necessary equipment & material, the student will test Schmitt trigger. Performance will be satisfactory if all requirements of text are met.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #14: Phase Shift Oscillator

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)
I. AUDIO FREQUENCY OSCILLATION NETWORKS II. PHASE SHIFT ANALYSIS III. FEEDBACK COMPENSATION IV. FREQUENCY DEVIATION	39. Without reference, the student will explain phase shift network operation. Performance will be satisfactory if the student meets requirements of the text. 40. Given necessary materials, the student will design phase shift oscillator. Performance will be satisfactory if all criteria set by Op Amp Handbook is met. 41. Given necessary equipment & materials, the student will test phase shift oscillator. Performance will be satisfactory if requirements listed in text have been completed.

TEL-160 IC & DISCRETE LINEAR APPLICATIONS

ASSIGNMENT #15: PIERCE OSCILLATOR

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)
I. CRYSTAL CHARACTERISTICS II. FREQUENCY STABILIZATION III. X, Y, & Z CUT CRYSTALS	42. Given temperature & frequency chart, the student will test crystal characteristics. Performance will be satisfactory if testing requirements in Op Amp Handbook are met.
IV. CRYSTAL OSCILLATORS	43. Given necessary materials, the student will design crystal oscillator. Performance will be satisfactory if all criteria set by Op Amp Handbook has been completed.
	44. Given necessary equipment & materials, the student will design crystal oscillator. Performance will be satisfactory if all requirements of text are met.
	45. Given necessary equipment & materials, the student will test crystal oscillator. Performance will be satisfactory if requirements of text are met.
	46. Without reference, the student will list oscillator operation. Performance will be satisfactory if standards set by the Op Amp Handbook are met.

TEL-160 LINEAR APPLICATIONS

Total Qty.	Qty./ Student	(Typical Part #) Item & Description
200	1	330 1/4 watt
200	4	1K 1/4 watt
400	2	1.5K 1/4 watt
200	1	1.8K 1/4 watt
400	2	2.2K 1/4 watt
400	2	3.3K 1/4 watt
700	4	4.7K 1/4 watt
200	1	8.2K 1/4 watt
400	1	9.1K 1/4 watt
400	2	10K 1/4 watt
200	1	12K 1/4 watt
200	1	15K 1/4 watt
400	2	22K 1/4 watt
200	1	33K 1/4 watt
200	1	39K 1/4 watt
400	2	47K 1/4 watt
200	1	68K 1/4 watt
200	1	82K 1/4 watt
300	3	100K 1/4 watt
600	3	150K 1/4 watt
400	2	220K 1/4 watt
200	1	270K 1/4 watt
200	1	330K 1/4 watt
400	2	470K 1/4 watt
200	1	510K 1/4 watt
200	1	680K 1/4 watt
400	2	1M 1/4 watt
200	1	1.5M 1/4 watt
200	1	2.2M 1/4 watt
200	1	3.3M 1/4 watt
400	2	3.9M 1/4 watt
200	1	6.8M 1/4 watt
600	3	47 Ω 1/2 watt
400	2	270 Ω 1/2 watt

TEL-160 LINEAR APPLICATIONS

Total Qty.	Qty./ Student	(Typical Part #) Item & Description
400	2	200 Ω 1/2 watt
600	3	470 Ω 1/2 watt
600	3	680 Ω 1/2 watt
200	1	1K 1/2 watt
200	1	10K 1/2 watt
400	2	270 Ω 2 watt
400	2	10K pots 1 watt 3/8" mount hole only
200	1	5 Ω 10 watt
200	1	47 Ω 1 watt
200	1	150 Ω 2 watt
200	1	680 Ω 1 watt
200	1	100K Trimmer Pot (Stand-Up PC Mount)
		CAPACITORS
200	1	1.5 pfd or 100 volt
200	1	3 pfd or 3.3 pfd 100 volt
200	1	6.8 pfd 100 volt
200	1	12 pfd 100 volt
200	1	22 pfd 100 volt
200	1	100 pfd 100 volt
400	2	150 pfd 100 volt
200	1	180 pfd 100 volt
200	1	220 pfd 100 volt
200	1	270 pfd 100 volt
400	2	330 pfd 100 volt
200	1	390 pfd 100 volt
200	1	470 pfd 100 volt
200	1	750 pfd 100 volt
200	1	.0015 ufd 100 volt
200	1	.0022 ufd 100 volt
200	1	.0047 ufd 100 volt
400	2	.01 ufd 100 volt
200	1	.039 ufd 100 volt
400	2	.068 ufd 100 volt
200	1	.082 ufd 100 volt
600	3	.1 ufd 100 volt
400	2	.22 ufd 100 volt
200	1	1.0 ufd 100 volt (Mylar)
200	1	3.0 ufd 50 volt

TEL-160 LINEAR APPLICATIONS

Total Qty.	Qty. Student	(Typical Part #) Item & Description
200	2	10 ufd 55 volt
200	1	250 ufd 25 volt
600	3	1000 ufd 50 volt #TC50100
400	2	.01 Disc
400	2	.1 Disc
200	1	1000 ufd 25 volt
		SEMICONDUCTORS
200	1	5 volt Reg #7805
200	1	15 volt Zener 5 watt
400	2	22 volt Zener 5 watt
400	2	Power Diodes 2 amp 100 PIV
200	1	Bridge 2 amp 100 PIV
400	2	2N404A
400	2	2N2714
400	2	2N2270
400	2	MTIP 41C TO-220 Case
200	1	MTIP 42C TO-220 Case
200	1	ECG 123A
200	1	555 Timer 8 pin dip
800	4	741C 8 pin dip
400	2	709C 8 pin dip
		MISCELLANEOUS PARTS & HARDWARE
1000	5	1 amp fuses 3 AG
200	1	2 amp fuse 3 AG
200	1	3 amp fuse 3 AG
175	1	48 VCT, 4A Transformer (perfer mntg. holes 2-3/4" x 2-1/2")
200	1	DPCT switch slide switch 3 amp (panel amount)
200	1	SPST switch toggle 3 amp
200	1	6 ft. line cord 18-2
400	2	3/8" nuts for potentiometer
200	1	Fuse holder chassis mount
1600	8	PC mount fuse holder clips
600	3	TO22 Mica insulators #956-1415 Allied
400	2	8 pin IC socket
175	1	Cabinet #WA1540 Bud

TEL-160 LINEAR APPLICATIONS

Total Qty.	Qty. Student	(Typical Part #) Item & Description
400	2	6 x 8 PC board 1 side copper (Cimclad or Epoxy)
200	1	15 pin connector AMP 530654-4 8045
800	4	Snap-in standoffs 1/2" PC to chassis mount
200	1	Strain relief for 13-2 (Must fit line cords)
600	3	TO5 radial heat sinks
400	2	3/8" grommets (size of hole in chassis)
200	1	1/2" grommet (size of hole in chassis)
600	3	Red binding posts (5-way)
600	3	Black binding posts (5-way)
200	1	White binding posts (5-way)
200	1	3 Lug tie strip (center grounded)
200	1	9" x 11" sheet #120 sheet metal screws
200	1	pad #1 or #0 steel wool
2400	12	#6 3/8" Flathead sheet metal screws
1200	6	#6 3/8" Machine screws
1200	6	"6 Hex head nuts
200	1	NE-2 Kit
400	2	Solder lugs for #6 screw
400	2	Knobs 1" w/indicator line, 1/4" shaft
4000	20	Cable ties 3-1/2"
175	1	Bud box AC-402
4	2	500 ft. Brown 18 gage insulated wire stranded
4	2	500 ft. Red 18 gage insulated wire stranded
4	2	500 ft. Black 18 gage insulated wire stranded
4	2	500 ft. White 18 gage insulated wire stranded
4	2	500 ft. Blue 18 gage insulated wire stranded
4	2	500 ft. Yellow 18 gage insulated wire stranded
16	8	Photo sensitive spray 16 oz. GC 22-231
8	4	Photo developer Gallon GC 22-235
6	3	5 gallons Etchant Kepro E-5G
16	8	Clear coat spray 12 oz. Katakoat Cat. #04177
4	2	500 ft. Red 22 gage wire solid
4	2	500 ft. Yellow 22 gage wire solid
4	2	500 ft. White 22 gage wire solid
4	2	500 ft. Blue 22 gage wire solid
4	2	500 ft. Brown 22 gage wire solid
4	2	500 ft. Orange 22 gage wire solid
4	2	500 ft. Black 22 gage wire solid
16	8	Heat sink compound 2 oz. tube

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. VIDEO DETECTORS

- A. See Slide Lecture
- B. Frequency Compensation

II. VIDEO SIGNALS AND AMPLIFIERS

- A. See Slide Lecture
- B. Composite Video Signal
- C. Picture Carrier
- D. Frequency Response
- E. Frequency Compensation
- F. D.C. Level of Video Signal
- G. Brightness, Contrast, & Picture Peak Controls Operation
- H. Video Blanking (V&H)
- I. Delay Lines
- J. Video Outputs (R, 6, B)
- K. Video Drivers Circuits
- L. Low Level Luminance Circuits

III. ZENITH SYSTEMS - 3 CIRCUITS

- A. Signal Flow
- B. Function of Each Circuit
- C. Troubleshooting Symptoms
- D. Simulated Defects

LAB 9

VIDEO AMPLIFIERS AND DETECTORS ---------- 9- 1

Color Block Diagram ---------- 9- 2

Lab Theory ---------- 9- 3

Typical Schematic ---------- 9- 5

Schematic (Systems-3) ---------- 9- 6

Lab Procedure ---------- 9- 7

Waveforms ---------- 9- 9

Simulated Defects ---------- 9-12

Test Pattern ---------- 9-15

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. I-F AMPS

- A. See Slide Lecture
- B. Hetrodyning and I-F Frequencies
- C. Sensitivity and Selectivity
- D. A.G.C. Bias
- E. Bandwidth and Frequency
- F. Wave Traps
- G. Stagger Tuning

II. SYSTEMS-3 CIRCUITS

- A. I-F Schematic
- B. De-Q-Ing Circuit
- C. S.W.I.F. Circuit

III. I-F ALIGNMENT

- A. See SAMS and Zenith Procedure
- B. Response Curve
- C. B/X Alignment Generator

LAB 10

PICTURE I-F AMPLIFIER -------------------- 10- 1

Color Block Diagram -------------------- 10- 2

Schematic (Systems-3) -------------------- 10- 3

Theory (General) -------------------- 10- 4

Theory (Systems-3) -------------------- 10- 5

Lab Procedure -------------------- 10- 6

B/K Alignment Generator -------------------- 10- 7

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. A.G.C. CIRCUITS

- A. See Slide Lecture
- B. Simple A.G.C.
- C. Rectified A.G.C.
- D. Amplified A.G.C.
- E. Keyed or Gated A.G.C.
- F. Noise Reduction Circuits
- G. A.G.C. Adjustments

II. ZENITH SYSTEMS - 3 CIRCUITS

- A. See Schematic
- B. See Lab Theory
- C. Troubleshooting Symptoms
- D. Bias Box Applications
- E. Simulated Defects

LAB II

AUTOMATIC GAIN CONTROL ------------------- 11- 1

Color Block Diagram -------------------- 11- 2

Theory ---------------------------------- 11- 3

Systems-3 Theory ----------------------- 11- 4

Schematic ------------------------------- 11- 5

Lab Procedure --------------------------- 11- 6

Simulated Defects ----------------------- 11- 8

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. TYPES OF TUNERS

- A. See Slide Lecture
- B. Bandswitch
- C. Drum or Turret
- D. Remote Control
- E. Varactor Tuners
- F. UHF "Converter"

II. ANTENNAS AND TRANSMISSION LINES

- A. Cable Characteristics
- B. Antenna Characteristics
- C. Signal Strength & Measurements
- D. Types of Antennas
- E. Cable Distribution Systems

III. TUNER REPAIR AND SERVICE

- A. Tuner Troubles
- B. R.F. Alignment
- C. Cleaning Techniques
- D. Exchange Procedure

LAB 12

V.H.F. and U.H.F. TUNERS ------------------ 12- 1

Theory ------------------------------------ 12- 2

Bandswitch VHF Schematic ------------------ 12- 3

Drum VHF Schematic ------------------------ 12- 4

Theory - Varactor Tuner ------------------- 12- 5

Service Guidelines ------------------------ 12- 6

Schematic of Varactor Tuner --------------- 12- 9

UHF Varactor Tuner Theory ----------------- 12-10

UHF Schematic ----------------------------- 12-14

Lab Theory - Systems-3 Tuner -------------- 12-15

Lab Procedure ----------------------------- 12-16

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. FM PRINCIPLES

- A. See Slide Lecture
- B. FM Characteristics
- C. FM Modulation
- D. Modulation Index and % of Deviation
- E. Transmission Characteristics
- F. Pre-Emphasis & De-Emphasis
- G. FM Detection
- H. Limiter Circuits
- I. Quadrature Detection

II. AUDIO OUTPUT

- A. Sound Chips
- B. D-C Volume Control

III. FM ALIGNMENT

- A. I-F Alignment Techniques
- B. Intercarrier Buzz
- C. I-F Peaking

IV. ZENITH SYSTEMS-3 CIRCUITS

- A. See Schematic
- B. Alignment Procedure
- C. Troubleshooting Symptoms
- D. Simulated Defects

LAB 13

SOUND DETECTOR & AUDIO OUPUT ------------------ 13- 1

Block Diagram ---------------------------------- 13- 2

Audio Section ---------------------------------- 13- 4

Lab Procedure ---------------------------------- 13- 5

Simulated Defect ------------------------------- 13- 6

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. COLOR SIGNAL MAKE-UP

- A. See Slide Lecture
- B. Color Circuits
- C. Color Block Diagram
- D. Color Camera Output
- E. Colorimetry
- F. Luminance Signal Make-Up
- G. Colorplexing
- H. R- , B- 6- Signal Make-Up
- I. Color Bar Generator Pattern
- J. Elimination of Green Transmission
- K. Chroma Signal Make-Up

II. COLOR CIRCUITS

- A. See Slide Lecture
- B. Chroma Amps
- C. Color Killer Circuit
- D. Chroma Signals
- E. A. C. C.
- F. Demodulator Circuits

III. ZENITH SYSTEMS-3 CIRCUITS

- A. See Manual and Schematic
- B. Chroma Amps
- C. A.C.C.
- D. Demodulators
- E. I-C Chip Signals
- F. Troubleshooting Symptoms
- G. Simulated Defects

LAB 14

COLOR AMPS AND DEMODULATOR ---------------- 14- 1
Color Block Diagram ---------------------- 14- 2
Color Signal Theory ---------------------- 14- 3
Theory: Color Processor ------------------ 14- 8
Systems-3 Theory ------------------------- 14-12
Color Signal Theory ---------------------- 14-13
Lab Procedure ---------------------------- 14-14
Color Signal Make-Up --------------------- 14-15
Waveforms -------------------------------- 14-16
Simulated Defects ------------------------ 14-17

TEL-200 COURSE CONTENTS: COLOR TELEVISION ANALYSIS

LECTURE

I. COLOR SYNC CIRCUITS

A. See Slide Lecture
B. Burst Signal
C. 3.58 MHz Oscillator
D. Demodulator Inputs
E. Loss of Color Sync

II. COLOR CIRCUIT ADJUSTMENTS

A. Color Killer Control
B. Automatic Phase Control (A.P.C.)
C. Automatic Color Control (A.C.C.)
D. Cross Talk Control
E. Tint Range

III. ZENITH SYSTEMS-3 COLOR SYNC CIRCUITS

A. See Schematic and Manual
B. 3.58 MHz Oscillator
C. Sync Chip
D. Tint Control and Lock
E. Troubleshooting Symptoms
F. Simulated Defects

LAB 15

COLOR SYNC CIRCUITS ---------------------- 15- 1

Color Block Diagram ---------------------- 15- 2

Systems-3 Theory ------------------------- 15- 3

Service Guidelines ----------------------- 15- 4

Lab Procedure ---------------------------- 15- 6

FINAL CHECK-OUT PROCEDURE ---------------- 15- 9

Article: Vector Scope Servicing --------- 15- 11

SYLLABUS

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

Vincennes University	Course Coordinator: R. Dean Eavey
Technology Division	Electronics Department Chairman
Electronics Department	Office: Room 312

Course Description:

Prerequisite TEL-110, 170. Corequisite SPH-101, SNT-150, BDP-114 or consent. The theory and application of microprocessors for control functions, software logic and processing data as applied to 8-bit machines. Topics such as architecture, instruction sets, assembly language, programming techniques and interfacing experiments are included as used in business and industry. 3 hours lecture, 5 hours lab.

Course Focus:

The student troubleshoots a Z80 microprocessor on a trainer to make operational, then focuses on programming the Z80 with experiments in interfacing.

Course Goals/Objectives:

The following goals will be accomplished in this course. Performance Based Objectives expanding on these goals may be found in Addendum A.

1. Make operational the computer
2. Operate the microprocessor
3. Write/run a simple output routine
4. Write relative branch program
5. Write/run a clock program
6. Interface a relay
7. Multiplex output program
8. Write/run input routine
9. Write run shift programs
10. Write/run a pushbutton routine
11. Write/run level change program
12. Identify circuits of the keyboard
13. Interface Z80 trainer
14. Write delay programs
15. Write shift & delay clock program
16. Write/run basic counter progrmams
17. Write/run self running counter
18. Write/run variable counter program
19. Write/run pre-settable counter program
20. Write/run logic simulation programs
21. Write a comparison program
22. Write/run program simulating 7447 decoder
23. Write/run addition programs
24. Write/run subtraction program
25. Write/run a multiplication program

Course Goals/Objectives (continued):

26. Write/run a division program
27. Write/run program to calculate the square
28. Interface ASCII keyboard
29. Generate text
30. Write/run a program to play tone
31. Write software music program
32. Build SC:01 Votrax synthesizer
33. Interface to trainer
34. Write interrupt routine
35. Write timer initialization routine
36. Write interrupt service routine
37. Construct application circuit
38. Report to class
39. Apply the TOSIII listing
40. Modify the boot to allow interfacing
41. Operate the Apple computer
42. Write an assemble language program

Course Reference:

Text: Z80 Programming Manual, by Osburn
Introduction to Microprocessors, by Osburn, Vol I.

Manual: TEL-230 Lab Manual, by Vincennes University Faculty

Other references not required.

Student Contributions:

All students are expected to adhere to the department rules & regulations, department attendance policy & VU student handbook of conduct. (See department rules & policies in lab manual.)

The student will build a processor on the trainer to use for the semester, then disassemble at end of course.

A comprehensive list of software will be created by the student for each of the 15 labs for his future reference.

Course Evaluation:

See Grading Policies in Addendum B.

Course Schedule:

There are 15 assignments, each designed for quality & quantity of work for one week of instruction. The schedule is to complete one assignment per week.

Classes meet four hours per day, twice weekly, totaling eight hours per week or 120 total hours. Lecture time will use 1/3 of the time and lab 2/3 of the time.

Penalty points may be given for late labs, extra credit given for additional lab work per lab.

For additional information see the lab manual or contact course coordinator listed on the front of this syllabi.

Grade Calculation:

$$\text{\% Grade to Date} = \frac{\text{Points Earned to Date}}{\text{Possible Points to Date}} \times 100$$

90 - 100 = A
80 - 89 = B
70 - 79 = C
60 - 69 = D
0 - 59 = F

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #1: Z-80 Architecture & Troubleshooting

ADDENDUM A

LECTURE OUTLINE

I. INTRODUCTION TO THE MICROPROCESSOR WORLD
  A. Generations of Electronics
  B. What is a Microprocessor?
  C. Applications of Microprocessors
    1. Data crunching
    2. Control
  D. Common μP Chips; F3, Z80, 6502, etc.
  E. Hardware Designs
  F. Complete Computer Systems
    1. The Mini-computer & microprocessor
    2. Peripheral devices
      a. Keyboards
      b. Video displays
      c. Memories
      d. Printers
      e. Floppy disc
      f. Cassette units
      g. Paper tape
      h. Etc.
  G. Precautions--Handling Chips (Static)

II. BASIC MIRCOPROCESSOR BLOCK DIAGRAM THEORY
  A. Memory: RAM & EPROM
  B. C.P.U.
    1. Program counter
    2. A.L.U.
    3. Registers
    4. Accumulator
    5. Instruction register
  C. P.I.O. (Input & Output Ports)
  D. Address & Data Base

III. MICROPROCESSOR POWER SUPPLIES
  A. System Requirements
  B. Regulators
  C. Crowbars & Overvoltage Protection
  D. Voltage Transients (M.O.V.)

IV. Z-80 ARCHITECTURE
  A. C.P.U. (3880)
    1. Accumulator 2. Arithmetic logic unit

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

I. Given the Z-80 microprocessor built in TEL-170 and Lab #1 of this course, the student will make operational the computer. Performance will be satisfactory if the student performs the following as outlined in Lab 1.

  A. Install chips
  B. Test & troubleshoot
  C. Repair as needed
  D. Run demo program

2. Given the Z-80 microprocessor trainer and operating instructions, the student will operate the microprocessor. Performance will be satisfactory if the student can successfully:

  A. Run music programs
  B. Load a program
  C. List a program
  D. Modify a program (edit)
  E. Run a program
  F. List out EPROM

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #1: Continued

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

3. Registers
4. Program counter
5. Instruction register
6. Control unit & instr. decoder
7. Stack pointer
8. Data counters
9. Interrupt
10. Flag resistors

B. P.I.O. (3881)
   1. Input port
   2. Output port
   3. Programmable port

C. Pin Description of 3880 & 3881

V. Z80 TRAINER SCHEMATIC THEORY
   A. C.P.U. & P.I.O.
   B. RAM & EPROM (Spec Sheets)
   C. Address Bus & Memory Decoder
   D. Data Bus
   E. Control Bus
   F. Buffers & Drivers (Spec Sheets)
   G. Fetch & Execute Cycles
   H. Program Flow Through Microprocessor

VI. HOW TO OPERATE & TEST A MICROPROCESSOR
   A. Microprocessor Trainer Instructions
   B. Hardware Precautions
   C. Check-Out Procedure
   D. Oscilloscope Checks
   E. Loading & Listing a Program
   F. Modifying & Running a Program

VII. TROUBLESHOOTING TECHNIQUES
   A. Address, Data & Control Buses
   B. Clock Waveform
   C. Memory Decoder
   D. Hardware or Software
   E. Logic Analyzer & Probes

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #2: Output Routines

ADDENDUM A

LECTURE OUTLINE

I. P.I.O. ARCHITECTURE & OUTPUT PORT

- A. Function & Operation of P.I.O.s
- B. LEDs & DRIVERS
- C. Testing Procedure
- D. Open & Closed Collectors
- E. Floating (TTL)
- F. Tri-State Devices (See spec sheets)
- G. Buffers (Tri-state & Bi-directional)
- H. 3881 Ports
- I. How to Program I/O

II. REVIEW OF NUMBER SYSTEMS

- A. Decimal & Power of 10s
- B. Binary
- C. Octal
- D. Hexidecimal
- E. Conversion of Base 10, 8, 16, 2
- F. Binary Addition & Subtraction (2s comp)
- G. Binary Multiplication & Division
- H. Addition in Base 8

III. ASSEMBLY LANGUAGE PROGRAMMING

- A. Flow Charting
- B. Source & Object Programs
- C. Assembly Language Syntax (Fields)
- D. Symbols for Assembly Language
- E. Some Mnemonics
- F. Assemblers
- G. Compilers
- H. Hand Assembling
- I. Line Numbers & Memory Location Differences

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

3. Given lab manual & microprocessor trainer, the student will write/run a simple output routine. Performance will be satisfactory if programs run and the student can output any combination of 8-bits at the output port and modify program for a JP instruction.

4. Given trainer, text & lab manual, the student will write relative branch program. Performance will be satisfactory if program runs & is written properly.

5. Given lab manual, text & trainer, the student will write/run a clock program. Performance will be satisfactory if student can run the program & calculate the time of T1 & T2 to 1 micro-second.

6. Given text, lab manual & trainer, the student will interface a relay. Performance will be satisfactory if the relay will set when program runs.

7. Given lab manual, trainer & test, the student will multiplex output program. Performance will be satisfactory if lab criteria is met for data out.

ASSIGNMENT #2: Continued

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

V. OUTPUT ROUTINES

A. Output Ports
B. Load Immediate Short
C. Output Short
D. Load Accumulator
E. Out Instruction
F. Unconditional Jump
G. Relative Branches
H. Nops
I. Calculating Instruction Cycles & Timing
J. Interfacing to a Relay

VI. INTERFACING

A. Relay Control
B. Buffer Amps
C. Timing
D. Interfacing a 74154
E. Output Program for 74154

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #3: Input Routines

ADDENDUM A

LECTURE OUTLINE

I. INPUT PORTS
   - A. Function & Operation
   - B. Switch Inputs
   - C. Testing Procedure

II. INPUT ROUTINES
   - A. Clearing Ports
   - B. Masking ("AND" Accumulator)
   - C. Input Ports
   - D. Shift Instructions
   - E. Rotate Instructions (RLA, RRCA, etc.)

III. SUB ROUTINES
   - A. Anology of Sub Routine
   - B. Symbols for Flow Charting
   - C. Memory--Call to Locations (Call Instructions)
   - D. Return Instruction

IV. DETECTING LEVEL CHANGES
   - A. Asynchronous I/O Routines
   - B. Synchronous I/O Routines
   - C. Pushbutton Routine
   - D. Simulating a Toggle Flip Flop
   - E. Mystery Program

V. OTHER INSTRUCTIONS USED IN THIS LAB
   - A. JR, NC
   - B. JR, C
   - C. INC REG
   - D. OR REG
   - E. LD A, B

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

8. Given trainer, text & lab manual, the student will write/run input routine. Performance will be satisfactory if the student can write a program that will input any combination of the 8-bits.

9. Given lab manual, texts & trainer, the student will write/run shift programs. Performance will be satisfactory if the student can make the L.S.B. shift right or left or any bit shift to any of the eight positions.

10. Given lab manual, trainer & text, the student will write/run a pushbutton routine. Performance will be satisfactory if given output displays when MSB switch is pushed.

11. Given text, lab manual & trainer, the student will write/run level change program. Performance will be satisfactory if the student uses a subroutine for pushbutton & operation of processor meets lab criteria.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #4: Interfacing A Hex Keyboard

ADDENDUM A

LECTURE OUTLINE

I. HEX KEYBOARD: HARDWARE DECODER
- A. Jameco #JE600 Kit Specs
- B. Circuit Theory
  - 1. HDO-165 Encoder
  - 2. 74LS123 M.V.
  - 3. 74LS175 Latches
  - 4. 74LS74 F.F. Functions
  - 5. Readouts
  - 6. Miscellaneous
- C. Interfacing to Z-80 Trainer

II. HEX KEYBOARD: SOFTWARE DECODER
- A. Theory
  - 1. Multiplexing on data bus (0-7, 8-F)
  - 2. 74LS138 Decoder for multiplexing
  - 3. I/O REQ Line to examine ADR0, 2
  - 4. RD Line
  - 5. EPROM Software basics
  - 6. Operation--Load #2
- B. Interfacing
  - 1. P.C. Board layout
  - 2. Templates
  - 3. Trainer interfacing

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

12. Given spec sheets on JE600 Keyboard, the student will identify circuits of the keyboard schematic. Performance will be satisfactory if the student can identify the function of each block division circuit of the schematic.

13. Given specs and documentation on the hex key pad and software encoder, the student will interface to Z-80 trainer to make operational a hex key pad with software encoding. Performance will be satisfactory if the unit loads & operates as specified in lab manual.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #5: Delay Routines

ADDENDUM A

LECTURE OUTLINE

I. DELAY ROUTINES
  - A. Decrement a Register
  - B. Register Countdown
  - C. Sub Routines
  - D. Call
  - E. Return or Pop
  - F. Flow Chart of Delays

II. APPLICATIONS OF DELAYS
  - A. Clock
  - B. Generate a Tone
  - C. Machine Control Timing
  - D. Input Data at Given Time
  - E. Scanners

III. DELAY PROGRAMS
  - A. Delay x 1 Routine
  - B. Delay 1 x 2 Routine
  - C. Clock with Delay
  - D. Clock with Delay 1 x 2 x 3
  - E. Shorter Versions of Delays (LD 2 Registers)

IV. SHIFT WITH DELAY PROGRAMS
  - A. Shift Instructions
  - B. Shift with Delay 1 x 2
  - C. Shift Right & Left with Delay 1 x 2
  - D. Shift in Random Patterns for Fun

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

14. Using reference and a work assignment to do either a 1 or 1 x 2 or 1 x 2 x 3 program, the student will write delay programs. Performance will be satisfactory if each program written runs.

15. Given microprocessor trainer, lab manual & text, the student will write shift & delay clock program. Performance will be satisfactory if the student can write a program to shift left with delay & shift left then right.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #6: Counter Programs

ADDENDUM A

LECTURE OUTLINE

I. SIMPLE COUNTERS
   - A. Self Running Counter
   - B. Pulsed Counter
   - C. Counters in Chips (7490 etc.)

II. BASIC COUNTER PROGRAMS
   - A. Up-Counter (Pulsed)
   - B. Down Counter (Pulsed)

III. SELF RUNNING COUNTER
   - A. Delay 1 x 2 with Clock to Pulse
   - B. Up or Down Self Running Counter

IV. VARIABLE COUNTERS
   - A. Variable Mod-Up Counter
   - B. 8-State Variable Mod Up-Counter

V. PRE-SETTABLE COUNTER
   - A. Count to a Given Number
   - B. Simulate an Industrial Counter

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

16. Given trainer, text & lab manual, the student will write/run basic counter programs. Performance will be satisfactory if the following can be written & run:
    - A. Up counter
    - B. Down counter, and
    - C. Mod-N Counter

17. Given flow chart & Z-80 programming manual, the student will write/run self running counter. Performance will be satisfactory if counter counts from 0-255 with 1/2 second delay.

18. Given trainer, lab manual, & text, the student will write/run variable counter program. Performance will be satisfactory if the following will run variable mod-up counter.

19. Given trainer, lab manual & text, the student will write/run pre-settable counter program. Performance will be satisfactory if program counts 0-15 and "shuts down" on pre-determined count.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #7: Logic Simulation

ADDENDUM A

LECTURE OUTLINE

I. BASIC LOGIC SIMULATION
   - A. Input & Output Routine Review
   - B. Inverter (Complement)
   - C. Astable
   - D. Monostable
   - E. AND Gate
   - F. OR Gate
   - G. Exclusive OR
   - H. Toggle Flip-Flop

II. COMPARISONS & STARCH TABLES
   - A. Using the Data Counter
   - B. Sorting Data
   - C. Generating Text
   - D. Name Search: Digital Phone Book

III. PROGRAM FOR 7-SEGMENT DECODER
   - A. 7447 Decoder
   - B. MAN-72
   - C. Output for One Number (0-F)
   - D. Data Counter & Data Table
   - E. Data Counter Program (Display 0-F)
   - F. Decoder/Encoder to Simulate 7447 and Encoder Input

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

20. Given Z-80 manual, lab manual & trainer, the student will write/run logic simulation programs. Performance will be satisfactory if the student can write/run a/an:
   - A. AND Gate
   - B. OR Gate
   - C. Monostable
   - D. Clock

21. Given lab manual, trainer & text, the student will write a comparison program. Performance will be satisfactory if program runs to select data from data table & display as detailed in lab manual.

22. Given materials & equipment listed on page - of lab manual & Z-80 programming manual, the student will write/run program simulating a 7447 decoder. Performance will be satisfactory if circuit operates as given in manual & student demonstrates to instructor.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #8: Microprocessor Arithmetic

ADDENDUM A

LECTURE OUTLINE

I. ADDITION
  A. Mod-2 Addition
  B. Input Techniques
  C. Add Instruction
  D. Pushbutton Routine
  E. Program Analysis

II. SUBTRACTION
  A. Two's Complement Subtraction
  B. Complement Instruction
  C. Addition Program

III. MULTIPLICATION
  A. Shift Techniques
  B. "Test" Techniques
  C. Input - Pushbutton
  D. Multiply by a Constant

IV. DIVISION
  A. Repetitive Subtraction
  B. Rotate Techniques
  C. Program Analysis

V. MULTIBYTE ARITHMETIC

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

23. Given lab manual, text & trainer, the student will write/run addition programs. Performance will be satisfactory if the following programs run:
  A. 8-bit addition
  B. 16-bit addition, and
  C. Select largest # in data table

24. Given trainer, lab manual & text, the student will write/run subtraction program. Performance will be satisfactory if program subtracts and can be modified to compare.

25. Given trainer, lab manual & text, the student will write/run a multiplication program. Performance will be satisfactory if the program will display the proper for and numbers less than 256 as the answer.

26. Given trainer, lab manual & text, the student will write/run a division program. Performance will be satisfactory if the number 2010 can be entered in hex and the #5 in hex is displayed when operating as lab manual instructs.

27. Given lab manual, text & trainer, the student will write/run program to calculate the square. Performance will be satisfactory if the binary #49 will cause a 7 to display.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #9: Interfacing A Video Terminal

ADDENDUM A

LECTURE OUTLINE

I. H-19 HEATH TERMINAL
  A. H-19 Manual - Theory
  B. ASCII Code
  C. Interfacing TTL
  D. Bi-Polar Interface for TTL
  E. RS-232 Standards

II. BAUD RATE SETTINGS
  A. Z-80 Trainer
  B. Heath H-19 Switches
  C. Heath H-19 from Keyboard

III. GENERATING TEXT FROM MEMORY
  A. Flow Chart Program

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

28. Given microprocessor trainer, lab manual schematics, the student will interface ASCII keyboard. Performance will be satisfactory if Heath terminal will display any program from labs 2-8 & processor will run program from terminal.

29. Given microprocessor trainer & lab manual, the student will generate text. Performance will be satisfactory if the student can display a page in his text containing text to use 1K or more of RAM.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #10: Timing Applications (Music)

ADDENDUM A

LECTURE OUTLINE

I. MUSIC FUNDAMENTALS

  A. Types of Notes - How to Read
  B. Timing
  C. Measure
  D. Octaves
  E. Keyboard

II. MICROPROCESSOR ORGAN

  A. Machine Control Fundamentals
  B. 8-Oscillator Schematic
  C. Interfacing Organ to Microprocessor

III. MUSIC PROGRAM

  A. Output to Key Note
  B. Delay for Space
  C. Delay for Note Timing
  D. Using Data Counter

IV. SOFTWARE MUSIC

  A. Nested Sub Routines
  B. Software Note
  C. Output One Note
  D. Counter Program

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

30. Given text, trainer & lab manual, the student will write/run a program to play tone. Performance will be satisfactory if tone is 1KHz ± 10% for one second ± 10%.

31. Given simple tune, flow chart, lecture & Z-80 manual, the student will write software music program. Performance will be satisfactory if the song sounds like the music reads in appendix of manual.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #11: Interfacing For Voice

ADDENDUM A

LECTURE OUTLINE	LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)
I. SC-01 VOICE SYNTHESIZER A. Spec Sheets B. Byte Article	32. Given parts & specs, the student will build SC-01 Votrax synthesizer. Performance will be satisfactory if circuit described in the lab will output phonic sounds. 33. Given Z-80 microprocessor trainer & SC-101 Votrax synthesizer, the student will interface to trainer. Performance will be satisfactory if the student can write programs to cause the Votrax to speak at least a 10 word sentence with clarity equal to the Hero I Robot.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #12: Interrupt Applications

ADDENDUM A

LECTURE OUTLINE

I. F-8 AND Z-80 SYSTEM

  A. Non-Maskable Interrupt
  B. F-8 Interrupt Modes
  C. Z-80 Interrupt Modes

II. INTERRUPT COMPATIBILITY

III. TYPES OF INTERRUPTS

  A. P10 Interrupts
  B. S10 Interrupts

IV. INTERRUPT EXAMPLES

  A. Start-Up
  B. Keyboard
  C. Printer
  D. Real-Time Clock
  E. Teletype

V. SERVICE ROUTINES

  A. Test Interrupt
  B. Output-Input for Control

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

34. Given trainer, lab manual & text, the student will write interrupt routine. Performance will be satisfactory if a given program running will stop & is displayed when interrupt is activated.

35. Given trainer, lab manual & text, the student will write timer initialization routine. Performance will be satisfactory if lab manual procedure runs.

36. Given trainer, text & lab manual, the student will write interrupt service routine. Performance will be satisfactory if a random binary generator is utilized to select interrupt time.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #13: Applications Programs

ADDENDUM A

LECTURE OUTLINE

I. APPLICATIONS PROGRAMS
  - A. A-D Conversion
  - B. D-A Conversion
  - C. Z-80 Stepping Motor Control
  - D. D-C Servo Motor Control (Res. Feedback)
  - E. Optical Feedback for Servo Motor Control
  - F. Morris Code Generation
  - G. Guess a Number Game
  - H. Dice Game
  - I. Game: Specify
  - J. Calendar Clock
  - K. 8-Stage Frequency Meter (Counter)
  - L. Microprocessor Light Show
  - M. Memory Expansion (Extra EPROM, Static or Dyn RAM)
  - N. Burglar Alarm System
  - O. Generate Text with Assembly Language or CRT
  - P. EPROM Burner (See Appendix D)
  - Q. Interfacing Printers
  - R. Interfacing Video Terminals (Other than Lab-9)
  - S. Other (As approved by instructor)

II. INSTRUCTIONS FOR REPORT
  - A. 15 Minute Report to Class by Student
  - B. Written Documentation
    - 1. Schematics, prints, etc.
    - 2. Circuit theory & instructions for operation

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

37. The student will construct one of the applications circuits listed under lecture outline I of this lab (13). Performance will be satisfactory if the circuit works according to specs for program.

38. The student will report to the class on a selected project & program. Performance will be satisfactory if the student presents an oral report and supports with written report.
  - A. Prepares a written report as described in lab manual
  - B. Presents a 15 minute oral presentation according to outline in manual
  - C. Prepares 5 question (multiple choice) test on oral and written reports

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #14: Bootstraps & Monitor Programs

ADDENDUM A

LECTURE OUTLINE

I. BOOTSTRAP (TOSIII)

   A. Input Switches=Switch Monitor
   B. Output Display
   C. Port Initialization
   D. Hex Keyboard Software
   E. Teletype Software
   F. Memory Transfer Software
   G. Cassette Input & Output Software
   H. Tiny Basic Option
   I. EPROM Copy Software
   J. EPROM Hardware (See Appendix D)
   K. Music Routines
   L. Unused EPROM
   M. Memory Mapping

II. ADDITION OF A SECOND P.I.O.

   A. Hardware
   B. Software Modification

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

39. Given the TOSIII, the student will apply the TOSIII listing. Performance will be satisfactory if a subroutine or game can be turned into an unused location of the EPROM.

40. Given the trainer and TOSIII Bootstrap, the student will modify the boot to allow interfacing a second P.I.O. Performance will be satisfactory if the P.I.O. is interfaced and one program can be run from labs 1-13 that will input & output from a second P.I.O. as well as the first P.I.O.

TEL-230 MICROPROCESSOR SOFTWARE & INTERFACING

ASSIGNMENT #15: Apple II Assembly Language

ADDENDUM A

LECTURE OUTLINE

I. 6502 INSTRUCTION SET

- A. Codes & Instruction Groups
- B. Appendix A of Handbook

II. OPERATING THE APPLE

- A. Floppy "Intro to the Keyboard"
- B. Calling Assembly Language
- C. Mini-Assembler
- D. Writing in Assembly Language (6502)

III. INTERFACING THE APPLE II

- A. Parallel Interface Card
  - 1. Circuit theory
  - 2. Interfacing
- B. Interfacing to a Protoboard
  - 1. Switches (Input instructions)
  - 2. Lamps (Output instructions)

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

41. Given manuals and Apple Computer, the student will operate the Apple Computer. Performance will be satisfactory if:
    - A. The student runs floppy "Intro to Keyboard"
    - B. Enters monitor program in hex
    - C. Examines & writes in memory in hex

42. Given manuals & Apple Computer, the student will write an assembly language program for the Apple II Computer. Performance will be satisfactory if the program is one that was written in Z-80 codes from labs 2-14 and is modified to 6502 codes using as a minimum requirement input & output instructions interfaced to a protoboard with switches & lights.

SYLLABUS

TEL-260 MICROPROCESSOR HARDWARE

Vincennes University
Technology Division
Electronics Department

Instructor:

Course Description:

This course provides technical experience in the construction, testing, programming and hardware design of a microprocessor as a computer or for industrial control. Each student will construct his own personal computer with CPU, I/O, Memory, ASC II keyboard and character generator. 2 hours lecture, 3 hours laboratory.

Course Focus:

The main focus of this course is to build and operate a microcomputer.

Course Goals/Objectives:

This course will address the following goals. Performance Objectives may be found in Addendum A.

1. Finish side panels
2. Fabricate chassis & keyboard plate
3. Paint metal chassis & keyboard plate
4. Assemble chassis, keyboard & panels
5. Solder components to video board
6. Solder option jumpers
7. Connect video board
8. Operate video board
9. Demonstrate video board
10. Solder components to keyboard
11. Solder components to video modulator
12. Assemble coax assembly
13. Interface video board, keyboard & modulator
14. Operate video terminal
15. Etch power supply pc board
16. Solder power supply components to pc board
17. Assemble complete supply
18. Test power supply output
19. Mount video board
20. Mount keyboard
21. Mount Rf modulator
22. Mount power supply
23. Interface video board, keyboard, Rf modulator & power supply
24. Test system,
25. Fabricate vector board
26. Install sockets
27. Wire wrap Vcc lines
28. Wire wrap ground lines

Course Gaols/Objectives (continued):

29. Wire wrap enable & write lines
30. Wire wrap miscellaneous lines
31. Mount clock components
32. Wire wrap clock
33. Scope clock output
34. Wire data bus lines to RAM, ROM, CPU & PIO
35. Check data bus for wiring error
36. Wire least significant bit address line
37. Check wiring of LSB wires
38. Wire wrap address decoder circuit
39. Check for wiring errors
40. Wire I/O pulse & reset lines
41. Wire I/O A data lines
42. Wire I/O B data lines
43. Check I/O A wiring
44. Fabricate I/O pc board
45. Assemble I/O board
46. Wire speaker
47. Wire TTL interface
48. Wire cassette I/O
49. Check wiring
50. Check +5 volts
51. Insert IC's
52. Play computer music
53. Load Basic into RAM
54. Enter Random Number game
55. Transfer game to cassette
56. Reset machine, load Basic from cassette, load game from cassette
57. Request instructor to play game
58. Take quizzes, midterm & final

Course References:

Text: Coffron, James W. & Long, William E., Practical Interfacing Techniques for Microprocessor Systems, Englewood NJ: Prentice-Hall, Inc., 1982

Course Evaluation:

See Addendum B.

Course Schedule:

This course meets for 15 weeks.

TEL-260 MICROPROCESSOR HARDWARE

ADDENDUM A

PERFORMANCE OBJECTIVES

1. Given wood side panels & finishing materials, the student will finish side panels. Performance will be satisfactory if: A) Wood sides sanded; B) Wood stained; C) Two coats of varnish applied; D) Sides steel wooled; and E) Sealing oil rubbed in.

2. Given metal chassis, keyboard plate, & metal working equipment, the student will fabricate chassis & keyboard plate. Performance will be satisfactory if: A) Keyboard plate cut per drawing 1; B) Chassis cut per drawing 1-B, C; and C) All holes deburred.

3. Given cut chassis & keyboard plate & finishing materials, the student will paint metal chassis & keyboard plates. Performance will be satisfactory if: A) All surface blemishes removed; B) Surfaces cleaned & prepared for paint; C) Primer coat applied; D) Two coats of color applied; E) Paint dried to hard finish; and F) Decals applied.

4. Given painted chassis, keyboard plate, cover plate, stained wood sides & hardware, the student will assemble chassis, keyboard & side panels. Performance will be satisfactory if: A) Sides securely attached to chassis; B) Piano hinge attached to chassis & keyboard plate; C) Plexiglass cover trimmed & set in place; D) Instructor inputs & approves the chassis & keyboard and signs Lab 1 sign-off sheet; and E) Student turns Lab 1 sheet into instructor.

5. Given video board components, the student will solder components to video board. Performance will be satisfactory if: A) Components mounted according to accompanying instructions; and B) All joints soldered properly.

6. Given soldered video board, the student will solder option jumpers. Performance will be satisfactory if: A) Option jumpers are installed as per page 2-37; and B) All joints soldered properly.

7. Given completed video board, the student will connect video board to "character generator jig". Performance will be satisfactory if: A) +8, ground & -16 volt lines connected; B) Composite video output to video monitor; C) ASCII keyboard unit properly to J1 on video board; and D) Temporary connector has been added to J2 pins 2 & 3 on video board.

8. Given video board completed, the student will operate video board. Performance will be satisfactory if: A) Monitor displays "clean" video; and B) Full character & cursor control is achieved.

9. Given video board completed, the student will demonstrate video board operation. Performance will be satisfactory if: A) Instructor approves operation; B) Instructor signs Lab 2 as completed; and C) Student turns in to instructor Lab 2 sign-off sheet.

10. Given keyboard components, the student will solder components to keyboard. Performance will be satisfactory if keyboard operated on lab jig.

11. Given video modulator components, the student will solder components to video modulator. Performance will be satisfactory if the video modulator works on lab jig.

12. Given the modulator board, 18" of shielded cable, and one RCA phono jack, the student will assemble coax assembly. Performance will be satisfactory if: A) RCA jack is soldered to shielded cable & checked for infinite continuity between center & shield; B) Other end of shielded cable is attached to input of Rf modulator as per instruction sheet; and C) Continuity has been checked to make sure cable is not shorted.

13. Given completed video board, keyboard & modulator, the student will interface video board, keyboard & modulator. Performance will be satisfactory if: A) Boards are interconnected as per Lab 3 instructions; B) All voltages are connected to video board & Rf modulator; and C) Rf modulator is attached to student TV set.

14. Given assembled video terminal components, the student will operate video terminal. Performance will be satisfactory if: A) TV displays "clean" video signal; B) Keyboard has complete control of cursor; C) Instructor inspects operation of terminal & signs Lab 3 sign-off sheet; and D) Student turns in Lab 3 papers.

15. Given printed circuit board material & lab facilities, the student will etch power supply printed circuit board. Performance will be satisfactory if: A) Etched board is etched "clean"; B) Board is trimmed on guidelines; C) Board is steel wooled; and D) Holes drilled as per Lab 4instructions.

16. Given the components & lab facilities, the student will solder power supply components to printed circuit board. Performance will be satisfactory if: A) All components are mounted securely; B) Wiring complies with drawing on pages 4-3 & 4-6 of lab manual; and C) All joints soldered.

17. Given completed power supply & power supply test jig, the student will assemble complete supply "breadboard" fashion. Performance will be satisfactory if all leads are attached to power supply as per tags attached to power supply test jig.

18. Given completed power supply board, the student will test power supply output. Performance will be satisfactory if all the listed voltages are correct: A) +5 volts regulated + or - .2v; B) -8 volts unregulated +3v; C) -12 volts regulated + or - .2v; D) +24 volts regulated + or - .2v; and E) Show results to instructor, have instructor sign sign-off sheet & turn it in.

19. Given finished chassis & video board, the student will mount video board. Performance will be satisfactory if: A) Video board mounted to chassis with 1/4" standoffs; and B) Oriented as per drawing in Lab 5.

20. Given keyboard plate & keyboard, the student will mount keyboard. Performance will be satisfactory if six 1/2", 5/8" or 3/4" standoffs are used to mount keyboard below surface of keyboard plate.

21. Given finished chassis, the student will mount Rf modulator. Performance will be satisfactory if Rf modulator is mounted as per instructor's model.

22. Given finished chassis & power supply, the student will mount power supply. Performance will be satisfactory if: A) Power supply is mounted with 1/4" standoffs; B) AC line & switches are installed; C) Accessory line plugs are wired; and D) Power supply retested for proper voltages.

23. Given finished chassis with power supply, Rf modulator & video board installed, the student will interface video board, keyboard, Rf modulator & power supply. Performance will be satisfactory if: A) Power supply is connected to video board +8 - gnd - and -12, Rf modulator +5 - gnd, Shielded cable between video board & modulator installed, and all cabling is put in neat bundles & cable straps attached; B) Keyboard is plugged into video board via 14 pin DIP connector; and C) Keyboard plate attached in side panels.

24. Given completed video terminal assembly, the student will test system. Performance will be satisfactory if: A) Chassis is plugged into AC outlet; B) Rf modulator feeds to TV set; C) Keyboard has complete control of cursor; and D) Instructor approves operation, signs Lab 5 sign-off sheet and student turns sign-off sheet into instructor.

25. Given vector board & standoffs, the student will fabricate vector board. Performance will be satisfactory if: A) Holes cut as per drawing on page 6-18; and B) Standoffs installed as per drawing.

26. Given fabricated CPU board, the student will install sockets. Performance will be satisfactory if: A) Sockets installed as per drawing on pages 6-17 & 6-18; B) Templates have been properly cabled as to IC number and type; C) Templates installed under sockets as per drawing on page 6-17; D) Tags containing IC number & type are glued next to IC socket on top of vector board; and E)

Instructor has approved work, signed sign-off sheet & student has turned sheet into instructor.

27. Given fabricated CPU board & wire wrap material, the student will wire wrap Vcc lines. Performance will be satisfactory if instructor approves wiring of IC sockets and Vcc lines as per drawing on page 7-9.

28. Given fabricated CPU board & wire wrap material, the student will wire wrap ground lines. Performance will be satisfactory if instructor approves of all ground lines wired as per drawing on page 7-10.

29. Given fabricated CPU board & wire wrap material, the student will wire wrap enable lines & write lines. Performance will be satisfactory if instructor approves that enable lines & write lines are wired as per drawing on page 7-11.

30. Given fabricated CPU board & wire wrap material, the student will wire wrap miscellaneous lines. Performance will be satisfactory if: A) Miscellaneous lines are wired as per drawing on page 7-11; B) Student's lab partner has checked wiring of ground, Vcc, enable, read, write & miscellaneous lines; and C) Student's lab partner has signed Lab 7 sign off sheet & student submits sheet to instructor along with CPU board for Lab 7 approval.

31. Given vector board & clock parts, the student will mount clock components. Performance will be satisfactory if; A) Components are mounted as per page 8-6 of lab manual; and B) Components are soldered to vector T-68 posts.

32. Given mounted clock parts & vector board, the student will wire wrap clock. Performance will be satisfactory if: A) Wire is wrapped as per schematic on page 8-8 of lab manual; and B) Student's lab partner has examined wiring for errors.

33. Given completed oscillator circuit, the student will scope clock output. Performance will be satisfactory if: A) Pulse is +5 volt amplitude square wave; B) Noise & overshoot less than .5vpp; C) Frequency is 2mhz + of - 5%; and D) Instructor has approved scope clock output & signed sign-off sheet.

34. Given CPU board & wire wrap material, the student will wire data bus lines to RAM, ROM, CPU, & PIO. Performance will be satisfactory if all lines are wired as per drawing on page 9-3 of lab manual.

35. Given CPU board with wire wrapped data lines, the student will check data bus for wiring error. Performance will be satisfactory if: A) Student has checked for correct wiring & placed a pencil mark through diagram lines as wires are checked; B) Checked for wires that are "extra"; and C) Student has lab partner check wiring.

36. Given CPU board & wire wrap material, the student will wire least significant bit address lines. Performance will be satisfactory if all lines are wired as per drawing on page 10-8 of lab manual.

37. Given CPU board with wire wrapped LSB address lines, the student will check wiring of LSB wires. Performance will be satisfactory if: A) Student has checked for correct wiring & placed a pencil mark through diagram lines as wires are checked; B) Checked for wires that are "extra"; and C) Student has lab partner check wiring.

38. Given CPU board & wire wrap material, the student will wire wrap address decoder circuit. Performance will be satisfactory if all lines are wired as per drawing on page 11-3 of lab manual.

39. Given CPU board with decoder wire wrapped, the student will check for wiring errors. Performance will be satisfactory if: A) Student has checked for correct wiring & placed a pencil mark through diagram lines as wires are checked; B) Checked for wires that are "extra"; and C) Student has lab partner check wiring.

40. Given CPU board & wire wrap materials, the student will wire I/O pulse & reset lines. Performance will be satisfactory if all lines are wired as per drawing on page 12-3.

41. Given CPU board & wire wrap materials, the student will wire I/O A data lines. Performance will be satisfactory if all lines are wired as per drawing on page 12-4 of lab manual.

42. Given CPU board & wire wrap materials, the student will wire I/O B data lines. Performance will be satisfactory if all lines are wired as per drawing on page 12-5 of lab manual.

43. Given CPU board with pulse, reset & I/O ports A & B wired, the student will check I/O wiring. Performance will be satisfactory if: A) Student has checked for correct wiring & placed a pencil mark through diagram lines as wires are checked; B) Checked for wires that are "extra"; and C) Student has lab partner check wiring.

44. Given printed circuit board & etch facilities, the student will fabricate I/O printed circuit board. Performance will be satisfactory if: A) PCB checked for "clean" etch; B) Cleaned with steel wool; C) Holes drilled & deburred; and D) Edges cut to proper size.

45. Given completed PCB & components, the student will assemble I/O board. Performance will be satisfactory if all parts are inserted as per drawing on page 13-3 & 13-4 of lab manual.

46. Given vector board, the student will wire speaker. Performance will be satisfactory if all parts are wired as per drawing on page 14-13.

47. Given CPU board & wire wrap materials, the student will wire TTL interface. Performance will be satisfactory if the circuit is wired as per drawing on page 14-15 of lab manual.

48. Given CPU board & wire wrap materials, the student will wire cassette I/O. Performance will be satisfactory if all lines are wired as per drawing on page 14-16 of lab manual.

49. Given CPU board with TTL interface & cassette I/O circuits wired, the student will check wiring. Performance will be satisfactory if: A) Student has checked for correct wiring & placed a pencil mark through diagram lines as wires are checked; B) Checked for wires that are "extra"; and C) Student has lab partner check wiring.

50. Given completed CPU board, the student will check +5 volts. Performance will be satisfactory if: A) Power supply is plugged into CPU board; and B) Voltages on top of each IC socket are checked for ground and +5 volts.

51. Given complete CPU board, the student will insert IC's. Performance will be satisfactory if: A) All IC's are placed in appropriate sockets; and B) Lab partner has checked for correct IC placement.

52. Given the completed microprocessor, the student will play computer music. Performance will be satisfactory if: A) The student plays the two tunes located in ROM; and B) Instructor hears music, signs sign-off sheet & student turns in Lab 14.

53. Given completed microprocessor, video monitor & tape recorder, the student will load Basic into RAM. Performance will be satisfactory if Basic interpreter loads into RAM according to instructions in Lab 15.

54. Given microprocessor with Basic loaded into RAM, the student will enter Random Number game. Performance will be satisfactory if student can play game properly.

55. Given microprocessor & tape recorder, the student will transfer game to cassette. Performance will be satisfactory if program transfers as per instructions in Lab 15.

56. Given microprocessor & tape recorder, the student will reset machine, load Basic from cassette & load game from cassette. Performance will be satisfactory if program transfers from cassette to RAM as per instructions in Lab 15.

57. Given microprocessor with game loaded into RAM, the student will request instructor to play game. Performance will be satisfactory if: A) Game plays for instructor; B) Instructor inspects project and signs-off Lab 15; and C) Student turns in Lab 15 to instructor.

58. Without references, the student will take quizzes, midterm & final. Performance will be satisfactory if answers are consistent with material related to text, performance objectives & other learning experiences.

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 1

I. INTRODUCTION TO MICROPROCESSOR HARDWARE
   A. Course Structure
   B. Grading Policy
   C. Project Description
   D. Project Scheduling
   E. Parts Policy

II. SIDE PANEL PREPARATION
   A. Wood Preparation
   B. Staining, Lacquer & Varnish Finishes

III. PREPARING CHASSIS & KEYBOARD PLATE
   A. Using Templates
   B. Metal Working with Aluminum

IV. ALUMINUM FINISHING
   A. Preparing Metal Surfaces
   B. Finish Types Used in Electronics
   C. Paint Spraying
   D. Applying Lettering

V. CHASSIS ASSEMBLY
   A. Hardware Types
   B. Case Assembly

LAB 1

ENCLOSURE CONSTRUCTION

The student will:

1. Finish side panels
2. Fabricate chassis, keyboard plate
3. Paint metal chassis, keyboard
4. Assembly chassis, keyboard, side panels

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 2

I. CHARACTER GENERATION
   A. The Keyboard
   B. The Video Board
   C. RF Modulator

II. VIDEO BOARD OPERATION
   A. CRT Operation
   B. Raster Scan Systems
   C. Character Generator Logic
   D. Screen Memory
   E. Manipulation of Screen Data
   F. CRT Timing Chain
   G. Sync Pulses
   H. Composite Video Signals

III. CHARACTER BOARD ASSEMBLY
   A. Plated Through Holes
   B. Parts Placement
   C. Jumpers Necessary
   D. Switch Set-Up on Video Board
      1. 32 or 64 Character
      2. RS-232C or TTY Loop
      3. Baud Rate
      4. Reversed Video
      5. Parity

IV. CONVERSION OF STANDARD TV SET FOR COMPOSITE VIDEO SIGNALS

LAB 2

VIDEO BOARD CONSTRUCTION

The student will:

5. Solder components onto video board
6. Solder option jumpers
7. Connect video board to "Character Generator Jig"
8. Operate video board
9. Demonstrate video board operation

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 3

I. ASCII CODE
  A. What it Looks Like
  B. How it is Used

II. ASCII ENCODED KEYBOARD
  A. Simple Decode Matrix
  B. Switch Matrix
  C. Scanning Keyboard
  D. The 2376 IC Encoder

III. RF MODULATOR
  A. Modulator Theory
  B. The Netronic Modulator

IV. INTERFACING
  A. Keyboard
  B. Video Board
  C. RF Modulator
  D. TV Set

V. COMPLETE OVERVIEW OF CHARACTER GENERATOR

LAB 3

VIDEO, KEYBOARD, MODULATOR INTERFACING

The student will:

10. Solder components into keyboard
11. Solder components into video modulator
12. Assemble coax plug
13. Interface video board, keyboard & modulator
14. Operate video terminal

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 4	LAB 4
I. POWER SUPPLY OVERVIEW A. Primary Circuit B. Eight Volt 4 Amp Circuit C. 32 Volt/1.5 Amp Circuit D. Full Wave Rectifiers E. +8 Volts Unregulated F. 7805 Regulators G. 7812 Regulators H. Negative Regulators II. FILTERING A. Capacitors - Filters B. Dipped Tantalum Caps III. COUPLING A. Molex Plug - 6" Cable B. Speaker Circuit IV. INSTALLATION IN CHASSIS A. Mount Power Supply B. Attack On/Off Switch on 6" Twisted Leads C. Tack Solder AC Cord Until Checks are Complete V. STATIC ELECTRICAL REQUIREMENTS A. TTL Structures B. IC Parameters C. Loading Requirements of Supplies	POWER SUPPLIES The student will: 15. Etch power supply printed circuit board 16. Solder power supply components to printed circuit board 17. Assemble complete supply "Breadboard" fashion 18. Test power supply's output

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 5

I. INTERFACING POWER SUPPLY TO:

- A. Video Board
- B. Keyboard
- C. RF Modulator

II. WIRING HARNESS

III. INTERFACING TTL LOGIC TO:

- A. CMOS Logic
- B. ECL Logic

IV. INTERFACING NON-TTL VOLTAGES

- A. Open Collectors
- B. Positive & Negative Pulses
- C. Optical Couplers
- D. Optical Isolators

LAB 5

CPU, TERMINAL & POWER SUPPLY

The student will:

19. Mount video board
20. Mount keyboard
21. Mount RF modulator
22. Mount power supply
23. Interface video board, keyboard, RF modulator & power supply
24. Test system

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 6

I. CHOOSING ENCLOSURES
   - A. Integrated Enclosures
   - B. Modular
   - C. Rack
   - D. Custom

II. CONNECTOR SYSTEMS

III. CIRCUIT BOARD CONSTRUCTION
   - A. Pointed Circuit Boards
   - B. Multilayer Boards
   - C. Wire-Wrap Boards
   - D. Solder & Sockets

IV. CIRCUIT BOARD LAYOUT
   - A. Routing
   - B. Assembly

V. HARDWARE ARCHITECTURE
   - A. Three Bus System
   - B. Address Buffers
   - C. Data Buffers
   - D. Control Buffers
   - E. Multiplexing Bus Systems

VI. TYPICAL BUFFERED BUSES
   - A. Intel 8085
   - B. Zilog Z-80

LAB 6

CENTRAL PROCESSOR BOARD PREPARATION

The student will:

25. Fabricate Vector Board
26. Install Sockets

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 7

I. THEORY OF WIRE WRAPPING

- A. Techniques
- B. Orders
- C. Applications
- D. Tools
- E. Color Coding
- F. Wire Wrap Rulse

II. OVERVIEW OF IC USAGE

III. VCC, GND, AND MISCELLANEOUS WIRING

IV. LAB PARTNER INSPECTIONS - WHY?

LAB 7

INTRODUCTION TO WIRE WRAPPING

The student will:

27. Wire wrap +5 Vcc lines
28. Wire wrap ground lines
29. Wire wrap enable & write lines
30. Wire wrap miscellaneous lines

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 8

I. CLOCK SIGNALS

- A. One Phase Systems
- B. Two Phase Systems
- C. Ideal vs. Typical Clock Pulses

II. PROCESSOR OPERATION SPEED

- A. Clock Speed
- B. Machine Cycle Time
- C. Instruction Time

III. PROCESSOR CLOCK

- A. What it Should Look Like
- B. How to "Clean it Up"
- C. Where It Goes

IV. THE S-100 BUS

- A. Configuration
- B. Mother Boards (Back plains)
- C. Power Requirements
- D. Bus Lines

LAB 8

CLOCK CONSTRUCTION AND ALIGNMENT

The student will:

31. Mount clock components
32. Wire wrap clock
33. Scope clock output

NOTE: DON'T SHORT-CUT THIS LAB--A POOR CLOCK WILL GIVE YOU NOTHING BUT TROUBLE.

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 9	LAB 9
I. INTERFACING DATA PATHS A. ROM B. Static ROM C. Common I/O Paths D. Separate I/O Memories E. Timing Considerations	DATA BUS LINES The student will: 34. Wire data bus lines to RAM, ROM, CPU & PIO 35. Check data bus for wiring error

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 10	LAB 10
I. I/O ARCHITECTURES	ADDRESS BUS LINES
A. Addressed Ports	The student will:
B. Device Ports	36. Wire least significant bit address lines
C. Linear Select	37. Check wiring of LSB wires
D. Memory Mapping	

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 11	LAB 11
I. ADDRESS DECODING A. How Much Memory 1. ROM 2. RAM B. Where is ROM & RAM II. DYNAMIC RAMS A. Basic Overview B. Row Address Strobe C. Multiplexing D. Column Address Strobe E. Delays III. REFRESH CIRCUITS A. Burst Refresh B. Clock Steal IV. INTERFACING DRAMS TO THE Z-80	ADDRESS DECODING The student will: 38. Wire address decoding circuit 39. Check for wiring errors

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 12

I. PI/O INTERFACING (3881 & 8255)
  - A. To CPU
  - B. To Port Inputs
  - C. To Port Outputs
  - D. Control Signals

II. THE DB-25 I/O PORT

III. I/O STANDARDS

IV. OTHER PI/O DEVICES
  - A. UART's
  - B. Printers
  - C. Disc Drives
  - D. Etc.

LAB 12

PARALLEL INPUT/OUTPUT INTERFACING

The student will:

40. Wire I/O pulse and reset lines
41. Wire I/O A data lines
42. Wire I/O B LED lines
43. Check I/O wiring

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 13	LAB 13
I. SERIAL INTERFACING A. Series vs. Parallels B. Baud Rates C. Parallel to Serial D. USART's II. TYPICAL SERIAL SYSTEMS A. RS232C B. IEEE 422 C. 20ma Loop D. DB-25 Standards	INPUT/OUTPUT BOARD CONSTRUCTION The student will: 44. Fabricate I/O printed circuit board 45. Assemble I/O board

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 14

I. CASSETTE I/O
   - A. Pulse Method
   - B. Audio Method
   - C. Phasing

II. DIGITAL TO ANALOG CONVERSION

III. ANALOG GO DIGITAL CONVERSION

IV. ROM SWITCH EXECUTIVE

LAB 14

PERIPHERAL INTERFACING

The student will:

46. Wire speaker
47. Wire TTL interface
48. Wire cassette I/O
49. Check wiring
50. Check +5 volts
51. Insert IC's
52. Play computer music

TEL-260 COURSE CONTENTS: MICROPROCESSOR HARDWARE

LECTURE 15

I. BOOTSTRAPS
   - A. Basic Bootstrap Operation
   - B. Basic in ROM
   - C. ROM Burner

II. USING THE ALTAIR BASIC
   - A. Loading
   - B. Dumping

LAB 15

MICROPROCESSOR OPERATION

The student will:

53. Load BASIC into RAM
54. Enter Random Number game
55. Transfer game to cassette
56. Reset machine, load BASIC from cassette, load game from cassette
57. Request instructor to play game

SYLLABUS

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

Vincennes University Technology Division Electronics Department	Instructor: Office-EB3;

Course Description:

TEL-255: A course specializing in industrial systems & control techniques. Applications include industrial power supplies, vacuum tubes, magnetic amps, syncrosystems, servo motors, stepping motors, photo devices, temperature systems, chemical transducers, motor speed control, three phase power, digital control, ladder diagrams with special emphasis on programmable controllers for industrial control. (Laser majors only.) 3 hours lecture, 5 hours laboratory.

TEL-275: Same as TEL-255 with more emphasis on sensors, transducers, and programmable controller applications. (Electronics & Robotics majors only.) 5 hours lecture, 7 hours laboratory.

Course Focus:

Emphasis is placed on electronic circuitry which controls industrial systems.

Course Goals/Objectives:

The following goals will be accomplished in this course.

1. Define 3 phase systems
2. Build 3 phase half wave rectification
3. Analyze 3 phase half wave rectification
4. Build 3 phase full wave rectification
5. Analyze 3 phase full wave rectification
6. Draw tube load line
7. Calculate vacuum tube DC components
8. Analyze vacuum tube DC circuit
9. Design vacuum tube AC components
10. Test vacuum tube AC amplifier
11. Analyze gas tube DC characteristics
12. Build gas tube rectifier circuit
13. Test gas tube rectifier circuit
14. Construct thyratron rectifier circuit
15. Measure thyratron characteristics
16. Analyze AC amplitude control of SCR
17. Test SCR phase shift control circuit
18. Control SCR using SUS
19. SCR & UJT control DC shunt motor
20. Perform dynamic braking & reversal of DC shunt motor
21. Analyze AC amplitude control of Triac

Course Goals/Objectives (continued):

22. Build SBS-Triac circuit
23. Test SBS oscillator
24. Control AC motor w/Diac and Triac
25. Build PM stepper circuit
26. Evaluate PM stepper control circuit
27. Build servos motor control circuit
28. Adjust servos motor circuit
29. Calculate relay dropping resistor
30. Evaluate relay logic circuit
31. Analyze discrete relay timer
32. Build integrated relay timer
33. Test integrated relay timer
34. Build photocell bulk level detector
35. Adjust photocell detection levels
36. Evaluate photocell controlled night light
37. Analyze infrared detector
38. Adjust LASCRs wired as SSR
39. Measure strain gage bridge circuit
40. Test strain gage direction detector
41. Evaluate thermocouple output levels
42. Build thermocouple controlled relay
43. Analyze thermistor controlled SCR
44. Build touch switch circuit
45. Test touch switch
46. Analyze proximity detector
47. Evaluate sound detector
48. Analyze power Mosfet
49. Draw switching power supply schematic
50. Build switching power supply
51. Adjust switching supply
52. Evaluate power Mosfet supply
53. Build relay ladder diagram circuit
54. Test relay ladder diagram circuit
55. Evaluate relay ladder diagram circuit
55. Evaluate relay ladder diagram circuit
56. Study programmable controller system
57. Program a PCU
58. Modify a PCU program
59. Design a PCU program
60. Load PCU timer program
61. Run PCU counter program
62. Evaluate PCU sequences function
63. Test PCU arithmetic function
64. Design PCU program
65. Load PCU arithmetic function
66. Evaluate PCU thumbwheel to register program
67. Test PCU transitional contacts
68. Run PCU register to table program
69. Design Modicom 484 PCU program

Course Reference:

Text: Driscall, Industrial Electronics Devices, Circuits & Applications, American Technical Society, 1981 Edition.

References: Maloney, Industrial Solid State Devices, Prentice Hall, 1982 Edition.

Student Contribution:

The student will be expected to take good care of industrial kits & pay for any damages while performing labs within one semester.

Course Evaluation:

The grading policy can be found in Addendum B.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #1: Power Sources

ADDENDUM A

LECTURE OUTLINE

I. POWER GENERATION

- A. AC Generators (Alternators)
- B. Transmission - Hi Tension Lines
- C. 60 Hz Three Phase

II. THREE-PHASE

- A. Wye (with neutral)
- B. Delta
- C. 120° Separation of Cycles
- D. 208v Between 110v Phases
- E. Half-Wave Rectification
- F. Full-Wave Rectification

III. RESIDENTIAL POWER

- A. 240-120 Supplies
- B. Household Plugs & Outlets

IV. THREE-PHASE RECTIFICATION

- A. Half Wave
- B. Full Wave

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 1, page 1, the student will:

1. Define three phase systems. Performance will be satisfactory when the student has passed the assignment and one test.
2. Build three phase half wave rectification. Performance will be satisfactory when the student has performed step 1 of lab 1.
3. Analyze three phase half wave rectification. Performance will be satisfactory when the student has performed steps 2-7 of lab 1.
4. Build three phase full wave rectification. Performance will be satisfactory when the student has performed step 8 of lab 1.
5. Analyze three phase full wave rectification. Performance will be satisfactory when the student has performed steps 9 & 10 of lab 1.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #2: Vacuum Tubes

ADDENDUM A

LECTURE OUTLINE

I. TUBE CONSTRUCTION

  A. Heater
  B. Cathode
  C. Plate
  D. Grids

II. TYPES OF TUBES

  A. Diode
  B. Triode
  C. Tetrode
  D. Pentode

III. TRIODE AMPLIFIER DESIGN

  A. Tube Curves
  B. DC Calculations
  C. AC Calculations
  D. Circuit Testing

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 2, page 1, the student will:

6. Draw tube load line. Performance will be satisfactory when the student has performed steps 1-6 in lab 2.

7. Calculate vacuum tube DC components. Performance will be satisfactory when the student has performed steps 7-9 of lab 2.

8. Analyze vacuum tube DC circuit. Performance will be satisfactory when the student has performed steps 10-13 of lab 2.

9. Design vacuum tube AC components. Performance will be satisfactory when the student has performed steps 14-17 of lab 2.

10. Test vacuum tube AC amplifier. Performance will be satisfactory when the student has performed steps 18-21 of lab 2.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #3: Gas Tubes

ADDENDUM A

LECTURE OUTLINE

I. GAS TUBE CONSTRUCTION

- A. Heater
- B. Cathode
- C. Plate

II. GAS TUBE TERMS

- A. Vaporization
- B. Ionization
- C. Arc Drop
- D. Deionization
- E. Arc Back

III. GAS DIODE

- A. Rectification
- B. Tube Conduction
- C. Waveforms

IV. GAS THYRATRON

- A. Rectification
- B. Tube Conduction
- C. Waveforms

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 3, page 1, the student will:

11. Analyze gas tube DC characteristics. Performance will be satisfactory when the student has performed steps 1-3 of lab 3.

12. Build gas tube rectifier circuit. Performance will be satisfactory when the student has performed step 4 of lab 3.

13. Test gas tube rectifier circuit. Performance will be satisfactory when the student has performed steps 6-9 of lab 3.

14. Construct thyratron rectifier circuit. Performance will be satisfactory when the student has performed steps 10-11 of lab 3.

15. Measure thyratron characteristics. Performance will be satisfactory when the student has performed steps 12-19 of lab 3.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #4: SCR Control of DC Motors

ADDENDUM A

LECTURE OUTLINE

I. SILICON RECTIFIER

II. SCR THEORY

- A. Operation
- B. Waveforms
- C. Control

III. SUS CONTROL

- A. SUS Theory
- B. Oscillators
- C. Waveforms

IV. DC SHUNT MOTORS

- A. Field
- B. Armature
- C. Speed Control & Braking
- D. Motor Reversal

V. UJT APPLICATIONS

- A. UJT Theory
- B. Oscillations
- C. Waveforms

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 4, page 1, the student will:

16. Analyze AC amplitude control of SCRs. Performance will be satisfactory when the student has performed steps 1-3 of lab 4.

17. Test SCR phase shift control circuit. Performance will be satisfactory when the student has performed steps 4-9 of lab 4.

18. Control SCR using SUS. Performance will be satisfactory when the student has performed steps 10-14 of lab 4.

19. SCR & UJT control DC shunt motor. Performance will be satisfactory when the student has performed steps 15-18 of lab 4.

20. Perform dynamic braking & reversal of DC shunt motor. Performance will be satisfactory when the student has performed steps 19-25 of lab 4.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #5: Triac Control of AC Motors

ADDENDUM A

LECTURE OUTLINE

I. TRIAC CONTROL
   - A. Triac Construction
   - B. Waveforms
   - C. RC Control

II. DIAC
   - A. Breakover levels
   - B. Oscillations

III. SBS
   - A. Breakover levels
   - B. Oscillators
   - C. Hysteresis

IV. UNIVERSAL MOTOR

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 5, page 1, the student will:

21. Analyze AC amplitude control of Triac. Performance will be satisfactory when the student has performed steps 1-4 of lab 5.

22. Build SBS-Triac circuit. Performance will be satisfactory when the student has performed step 5 of lab 5.

23. Test SBS oscillator. Performance will be satisfactory when the student has performed steps 6-9 of lab 5.

24. Control AC motor with Diac & Triac. Performance will be satisfactory when the student has performed steps 10-16 of lab 5.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #6: Stepper & Servos Motors

ADDENDUM A

LECTURE OUTLINE

I. STEPPER MOTORS
  - A. Rotor & Poles
  - B. Sequence of Poles
  - C. Stopping & Reversing

II. STEPPER CONTROLS
  - A. 555 Astable
  - B. Decoder-Driver

III. DC SERVOS CIRCUIT
  - A. Input Voltage
  - B. Motor
  - C. Feedback Voltage

IV. DIGITAL PROPORTION CONTROL CIRCUIT
  - A. Astable
  - B. Inverter
  - C. Servos Positioning

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 6, page 1, the student will:

25. Build PM stepper circuit. Performance will be satisfactory when the student has performed step 1 of lab 6.

26. Evaluate PM stepper control circuit. Performance will be satisfactory when the student has performed steps 2-5 of lab 6.

27. Build servos motor control circuit. Performance will be satisfactory when the student has performed step 6 of lab 6.

28. Adjust servos motor circuit. Performance will be satisfactory when the student has performed steps 7-11 of lab 6.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #7: Relays

ADDENDUM A

LECTURE OUTLINE

I. RELAYS
   - A. Coils
   - B. Contacts
   - C. Logic
   - D. Semiconductor Protection Diode

II. RELAY TIMERS
   - A. Discrete (2N2270)
   - B. Integrated (555)

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 7, page 1, the student will:

29. Calculate relay dropping resistor. Performance will be satisfactory when the student has performed step 1 of lab 7.

30. Evaluate relay logic circuit. Performance will be satisfactory when the student has performed steps 2-4 of lab 7.

31. Analyze discrete relay timer. Performance will be satisfactory when the student has performed steps 5 & 6 in lab 7.

32. Build integrated relay timer. Performance will be satisfactory when the student has performed step 7 of lab 7.

33. Test integrated relay timer. Performance will be satisfactory when the student has performed steps 8-12 of lab 7.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #8: Optical Devices

ADDENDUM A

LECTURE OUTLINE

I. CATEGORIES OF OPTICAL DEVICES
  A. Photoemissive
  B. Electroluminescent
  C. Photovoltaic
  D. Photoconductive

II. PHOTOCELLS
  A. Photovoltaic
  B. Photoresistive

III. LEDs
  A. Colors
  B. Intensity

IV. PHOTODIODES

V. PHOTOTRANSISTORS

VI. LASCR

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 8, page 1, the student will:

34. Build photocell bulk level detector. Performance will be satisfactory when the student has performed step 1 of lab 8.

35. Adjust photocell detection levels. Performance will be satisfactory when the student has performed steps 2-5 of lab 8.

36. Evaluate photocell controlled night light. Performance will be satisfactory when the student has performed steps 6-10 of lab 8.

37. Analyze infrared detector. Performance will be satisfactory when the student has performed steps 11-17 of lab 8.

38. Adjust LASCRs wired as SSR. Performance will be satisfactory when the student has performed steps 18-20 of lab 8.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #9: Thermal & Strain Sensors

ADDENDUM A

LECTURE OUTLINE

- I. STRAIN GAGES
  - A. Construction
  - B. Resistance Change
  - C. Temperature Compensation
  - D. Strain Amplifier
- II. THERMOCOUPLE
  - A. Construction
  - B. Temperature Effects
  - C. Thermal Detection
- III. RTDs
- IV. THERMISTORS
  - A. Construction
  - B. Temperature Coefficient
  - C. Circuit Application

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 9, page 1, the student will:

39. Measure strain gage bridge circuit. Performance will be satisfactory when the student has performed steps 1-5 of lab 9.

40. Test strain gage direction detector. Performance will be satisfactory when the student has performed steps 6-11 of lab 9.

41. Evaluate thermocouple output levels. Performance will be satisfactory when the student has performed steps 12-15 of lab 9.

42. Build thermocouple controlled relay. Performance will be satisfactory when the student has performed steps 16-19 of lab 9.

43. Analyze thermistor controlled SCR. Performance will be satisfactory when the student has performed steps 20-25 of lab 9.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #10: Touch, Proximity & Sound Sensors

ADDENDUM A

LECTURE OUTLINE

I. TOUCH SWITCHES
    A. Input Signal
    B. Amplifier
    C. Control Circuit

II. PROXIMITY DETECTOR
    A. Oscillator
    B. Rectifier
    C. Comparator
    D. Loading of Oscillator

III. SOUND DETECTOR
    A. Input Signal
    B. Amplifier
    C. Control Circuit

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 10, page 1, the student will:

44. Build touch switch circuit. Performance will be satisfactory when the student has performed step 1 of lab 10.

45. Test touch switch detector. Performance will be satisfactory when the student has performed steps 2-6 of lab 10.

46. Analyze proximity detector. Performance will be satisfactory when the student has performed steps 7-11 of lab 10.

47. Evaluate sound detector. Performance will be satisfactory shen the student has performed steps 12-15 of lab 10.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #11: Power Mosfets & Switching Power Supplies

ADDENDUM A

LECTURE OUTLINE

I. POWER MOSFETS
   A. FET Operation
   B. CMOS Construction
   C. Switching Rate
   D. No Thermal Runaway

II. SWITCHING POWER SUPPLIES
   A. Input Rectification
   B. Power Switching
   C. Hi-Speed Transformers
   D. Output Rectification
   E. Error Amp
   F. Pulse Width Modulator

III. ADJUSTING SWITCHING SUPPLIES
   A. Error Amplifier
   B. Pulse Width Modulator

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed on Lab 11, page 1, the student will:

48. Analyze power mosfets. Performance will be satisfactory when the student has performed step 1 of lab 11.

49. Draw switching power supply schematic. Performance will be satisfactory when the student has performed step 2 of lab 11.

50. Build switching power supply. Performance will be satisfactory when the student has performed step 3 of lab 11.

51. Adjust switching supply. Performance will be satisfactory when the student has performed step 4 of lab 11.

52. Evaluate power mosfet supply. Performance will be satisfactory when the student has performed steps 5-6 of lab 11.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #12: Ladder Diagrams

ADDENDUM A

LECTURE OUTLINE

I. LADDER DIAGRAM SYMBOLS
   - A. Contacts
   - B. Lamps
   - C. Coils
   - D. Resistors
   - E. Capacitors

II. LADDER DIAGRAM ABBREVIATIONS
   - A. Functions
   - B. Devices
   - C. Letters

III. LADDER DIAGRAM STRUCTURE
   - A. Power Bars
   - B. Power Flow
   - C. Relay vs. Contacts
   - D. Sequence

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 12, page 1, the student will:

53. Build relay ladder diagram circuits. Performance will be satisfactory when the student has performed steps 1, 4, 7, 10 & 13 of lab 12.

54. Test relay ladder diagram circuits. Performance will be satisfactory when the student has performed steps 2, 5, 8, 11 & 14 of lab 12.

55. Evaluate relay ladder diagram circuits. Performance will be satisfactory when the student has performed steps 3, 6, 9, 12 & 15 of lab 12.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #13: Programmable Controllers

ADDENDUM A

LECTURE OUTLINE

I. DIGITAL CONTROLLERS
  - A. Discrete Devices (Relays)
  - B. Drum Controllers
  - C. Computers

II. PCU HARDWARE
  - A. CPU
  - B. Memory
  - C. Terminals
  - D. I/C Modules (DC & AC)

III. PCU SOFTWARE
  - A. System Controls
  - B. Ladder Diagram Programs
  - C. Diagnostic Aids

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 13, page 1, the student will:

56. Study programmable controller systems. Performance will be satisfactory when the student has passed the assignment #13 test.

57. Program a PCU. Performance will be satisfactory when the student has performed steps 1-15 of lab 13.

58. Modify a PCU program. Performance will be satisfactory when the student has performed steps 16-37 of lab 13.

59. Design a PCU program. Performance will be satisfactory when the student has performed steps 37-40 of lab 13.

TEL-255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #14: Modicom M-84 PCU Applications

ADDENDUM A

LECTURE OUTLINE

I. M-84 FUNCTIONS
  A. Timers
  B. Counters
  C. Sequencers
  D. Arithmetic

II. PROGRAM PACK
  A. Dump
  B. Load

III. PROGRAMMING
  A. Oscillators
  B. Pulse Counters
  C. Weighted Sequencers
  D. T-Flip Flop

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 14, page 1, the student will:

60. Load PCU timer program. Performance will be satisfactory when the student has performed steps 1-6 of lab 14.

61. Run PCU counter program. Performance will be satisfactory when the student has performed steps 7-10 of lab 14.

62. Evaluate PCU sequencer function. Performance will be satisfactory when the student has performed steps 11-15 of lab 14.

63. Test PCU arithmetic function. Performance will be satisfactory when the student has performed steps 16-18 of lab 14.

64. Design PCU program. Performance will be satisfactory when the student has performed steps 19 & 20 of lab 14.

TEL 255 & 275 INDUSTRIAL ELECTRONICS CONTROL

ASSIGNMENT #15: Modicom 484 PCU Applications

ADDENDUM A

LECTURE OUTLINE

I. 484 CONTROLLER SYSTEM
  A. Processor
  B. Power Supply
  C. I/O
  D. CRT Terminal

II. 484 PROGRAMMING
  A. Networks
  B. I/O References
  C. Memory Protect

III. 484 FUNCTIONS
  A. Equivalent to M-84
  B. Multipy & Divide
  C. BCD-Reg & Reg-BCD
  D. Transitional Contacts
  E. SKIP
  F. Network Delete
  G. Register - Table & Table - Register

LAB: PERFORMANCE BASED TRAINING OBJECTIVES (PBT)

Given the materials & equipment listed in Lab 15, page 1, the student will:

65. Load PCU arithmetic program. Performance will be satisfactory when the student has performed steps 1-3 of lab 15.

66. Evaluate PCU thumbwheel to register program. Performance will be satisfactory when the student has performed steps 4 & 5 of lab 15.

67. Test PCU transitional contacts. Performance will be satisfactory when the student has performed steps 6 & 7 of lab 15.

68. Run PCU register to table program. Performance will be satisfactory when the student has performed steps 8 & 9 of lab 15.

69. Design Modicom 484 PCU program. Performance will be satisfactory when the student has performed steps 10-12 of lab 15.

(TENTATIVE) TRO-210

PART II: AIR LOGIC CONTROLS

1. Fundamentals of Air Logic Control
2. Review of Pneumatic Components, Symbology and Circuitry
3. Review of Air Cylinder Control
4. Moving Part Logic Components--Time Delay
5. Converting Signals from Momentary to Maintained
6. Converting Signals from Maintained to Momentary
7. Sensing
8. Basic Pneumatic Detached Symbology
9. Information Gathering
10. Basic Design Technique
11. Circuit Design of a Roll Forming Machine
12. Two Hand Non-Tie Down Control Variations
13. Air Preparation
14. Fabrication and Installation
15. Troubleshooting

PART III: ELECTRO-MECHANICAL CONTROL OF FLUID POWER

1. Basic Electricity for Fluid Power Control
2. Solenoids & Relays
3. Directional-Control Valves, Two-Position, Solenoid-Operated
4. Directional-Control Valves, Three-Position, Solenoid-Operated
5. Electrical Symbols & Schematic Diagrams
6. Electrical Switches
7. Relay Circuits
8. Reciprocation of Air Cylinders
9. Reciprocation of Hydraulic Cylinders & Pump Unloading
10. Sequencing of Cylinders
11. Timing Devices and Circuits
12. Photo-Electric Devices and Circuits
13. Cylinder Dwell
14. Peck Drilling
15. Safety Circuits

TRO-250

ROBOTIC APPLICATIONS

1. Motion Mate Robot: Programming, Interfacing, Applications & Servicing
2. Seiko #400 Robot: Programming, Interfacing A/B Applications & Servicing
3. Thermwood Series 7: Programming, Interfacing, Applications & Servicing
4. Milacron T3 Electric: Programming, Interfacing, Applications & Servicing
5. Thermwood Paintmaster: Programming, Interfacing, Applications & Servicing
6. Cartesian Robot: Programming, Interfacing, Applications & Servicing
7. Conveyer Systems with A/B Programmable Controllers
8. Cybotech Robot #: Programming, Interfacing, Applications & Servicing
9. Application of Vision Systems & Servicing
10. Application Engineering of a Product for Robot Manufacturing
11. Robot Line Sync Control to Conveyer
12. Interfacing Robots to Manufacturing Equipment
13. Troubleshooting Robotized Manufacturing Processes
14. Manufacturing Servicing of Robotized "Factory of the Future"
15. C.V. CAD/CAM Control of Robot Cells

VINCENNES UNIVERSITY
ELECTRONICS TECHNOLOGY DEPARTMENT

ADDENDUM B

GRADING POLICIES

1. Goal:

Fairly evaluate a students technical level of understanding and practical performance of laboratory work.

2. Objectives:

A. To distinguish & recognize levels of student achievement to course standards as given:

A = Excellent, B = Good, C = Average, D = Poor, F = Failed

B. To indicate to industry by the above grades that, for example, an "A student" is excellent and is the best out department can produce, a "C student" is our average student.

C. To encourage students to study & know reading assignments, lecture notes and lab manual material.

D. To encourage excellence in quality of lab work performance.

E. To encourage the student to produce the required quantity of work in lab assignments.

3. Course Grading Structure:

To help understand grading, the structure of each course is given below.

A. Each course is based on a 15 week semester (1 additional week for final exams).

B. Each course is divided into 15 units of instruction (called labs). One unit per week equally weighted for grading.

C. Each course will have 15 unit test (one per lab) with each assigned points for a total given number of points for tests.

D. Each course will have 15 lab assignments requiring an instructor's signature indicating that parts of that lab assignment & then the total lab assignment has been done satisfactorily and credit is given. (No grade of A, B, C, D, F.) If the lab is satisfactory, the student must re-do to obtain the instructor's signature.

Labs are used in the evaluation process to evaluate performance. Test grades & project grades will determine the student's total grade if the student has completed his lab work.

The student qualifies for an "A" in the course if all 15 labs completed, the student's test & project grades indicate he is doing "A" work, he receives an A. However, if the student's test & project grades indicate a "C", he will get a "C", even if he is qualified for a "A" in lab work. The following scale indicates the minimum performance level required.

A = 15 labs
B = 14 labs
C = 13 labs
D = 12 labs
F = 11 or less

It is obvious that the student must have 12 or more labs to qualify for a passing grade. Even if the student has an "A" average on test, he must have 12 labs to pass (D); this is unlikely.

Note: Forgery is cause for dismissal from the course. Only instructor's signature will appear on lab sheets.

E. Each course has lab experiments & usually a project. A grade of A, B, C, D, or F will be given for the quality of work on that project. The grade will be converted to points to be averaged into the student's total grade. Much of the grading will be based on the subjective judgement of the project. However, a list of criteria will be given for each project indicating items such as soldering, chassis work, painting, wiring dress, layout, design improvements, etc. The standard grade scale will be used for point conversion.

To earn an "A", the project must meet all criteria standards indicating that this is the best the department expects from students.

F. With 15 tests given, one per week, no mid-term will be given, however, a comprehensive final exam will be given which will be 10% of course grade total.

4. Evaluation Sources:

Students will be evaluated on the following:

A. Test (theory & performance)
B. Lab assignments
C. Project grade
D. Final exam

Test material comes from three sources:

A. Reading assignments (given on first page of each lab assignment
B. Lecture material (outlined in front of lab manual)
C. Lab manual (see PBT objectives in lab manual & reading material in lab manual)

*Note: Test may include a performance section on lab material.

5. Grading Scale:

A = 90 - 100%
B = 80 - 89%
C = 70 - 79%
D = 60 - 69%
F = 0 - 59%

Grade calculation formula:

$$\% = \frac{\text{points earned}}{\text{points possible}} \times 100$$

Note: A student may calculate his grade at any time throughout the course since he knows the total points possible.

Point System

Each test will receive equal weight since each lab unit (one per week) was designed to cover an equal weight of material.

15 tests, 50 points each = 750 (75%)
Project points = 150 (15%)
Final exam = 100 (10%)

1000 points

No points are given for lab assignments approved. As explained, "labs" become a qualifier, students receive the grade from test points, and final exam points earned *if* they qualify by having completed the required lab assignments.

7. Examples:

78% and 11 labs = F
78% and 12 labs = D
78% and 13 labs = C
78% and 14 labs = C
78% and 15 labs = C

98% and 13 labs = C
88% and 13 labs = C
78% and 13 labs = C
68% and 13 labs = D
58% and 13 labs = F

8. Examples of Project Criteria:

A. The project for TEL-230 will be developed in Lab 13: Microprocessor Applications, where each student will construct a protoboard project to interface to the Z-80 microprocessor. Neatness will be a major criteria along with the write-up that the student develops with his research. Maximum points possible 100.

B. 50 points will be assigned by the instructor in other labs involving interfacing such as the keyboard (hex), etc.

9. Student Record

	Earned Pts.	Possible Pts.		
Test# 1			Lab # 1	
# 2			# 2	
# 3			# 3	
# 4			# 4	
# 5			# 5	
# 6			# 6	
# 7			# 7	
# 8			# 8	
# 9			# 9	
#10			#10	
#11			#11	
#12			#12	
#13			#13	
#14			#14	
#15			#15	
Sub-total				
Final points				
Project points				
TOTAL POINTS				

10. Attendance & Make-up

I. All students are required to attend all classes & labs.

A. Excused absences must be approved by both the Dean of Students & the instructor of the course with consent of the department chairmen.

B. The student will automatically be dropped for non-attendance upon the sixth (6th) absence (excused or not). Instructor should warn student upon third (3rd) absence.

C. Test must be made up within one week or zero points will be given.

D. $10.00 will be charged per test for unexcused make-up tests.

II. Labs will be due on the day the test is given for the same section.

A. Late labs must be made up within one week of the due date or no credit will be given.

B. Labs must be done in pencil (no ink or erasable ink) for the purpose of corrections.

III. No labs or tests may be made up after the last day of class. Which means there is no one week make-up period for the last lab & the last test. There will be no make-ups during final exam week.

Equipment

Three new labs became part of the Robotics Program. Those labs are:

1. Intro and Interfacing Lab: Used by first year students for the introductory course (TRO 150) and by second year students for the TRO 200 Interfacing course the opposite semester. (1200 sq. ft.)

2. Hydraulics & Pneumatics Lab: Used for SNT 160 course first semester and for TRO 210 Hydraulics and Pneumatics Control. (1200 sq. ft.)

3. Robotic Application Lab: This lab will be used for TRO 250 by a group of students for the semester to set up a manufacturing system. During the first semester, this lab can also be used for the servicing course (TRO 210). The robots used are industrial size. (200 sq. ft.)

Equipment List:

12	Benches
24	Stools with backs
12	Rhino Robot Trainers
12	Apple Computers with CRT, Floppy and Interfacing Cards
12	Micro Bot Robot Trainers
4	Hero Robots
12	Hydraulic/Pneumatic Trainers (Labvolt by T.S.I.)
12	Electro-mechanical Trainers
6	Air Logic Trainers
12	Allen-Bradley Programmable Controllers
12	Sets of I/O and A/D Cards
2	Modicom Programmable Controllers
1	Conveyor System (Pallet Type)
1	Milacron T-3 (726) Electric Robot
1	Co2 50 watt Laser with Articulating Arm
1	Painting Robot
1	Binks Paintmaster
1	Seiko #400 Pneumatic Robot
1	Motion Mate Pneumatic Robot
1	Hydraulic Robot - Thermwood Series 7 (for palletizing)
1	Spot Welder
4	Heavy Duty Benches
	End Effectors
1	Cartesian Robot - #20 Thermwood
1	Precision Assembly Robot
12	Sets of Robotic Controls & Interfacing Components
	Misc. Tools and Equipment

To date, there are no graduates of the program. It is planned that the technician will be capable of entering industry to repair, maintain, do various applications such as welding, painting, handling, palletizing, picking and placing, and any other feasible application.

Faculty

Dean Eavey (Department Chairman) - 14 years at Vincennes University in Electronics, technical trade experience
Brian Blanford - 11 years experience - Thermwood, ITT
Dennis Shappard - 13 years at Vincennes University

Placement

Students are currently in their first year now, placement will occur in one year. Some interviews are going on now for eight double majors.

PROGRAM: Robotic Technician Program
INSTITUTION: Staples Technical Institute
3rd Street North
Staples, Minnesota 56479
(218)894-2430
CONTACT: David W. Carroll
DEGREE: Two-Year Associate Degree
DATE BEGAN: February 1983

History

The first meeting of a Robotic Technician Advisory Committee was held in August, 1982. At that time it was recommended by the advisory committee, in conjunction with the administration of Staples Technical Institute, that a program be established. The objective was to train eighteen students as robotic technicians. Of specific importance, the proposed program would allow a cooperative approach with other already-existing programs. Tool and Die, Tool Room Machinist, Plastic Mold Injection Making, Electro-Mechanical Drafting, Phototronics, Related Hydraulics and a proposed Microcomputer Repair Technician Program would be direct resources for the Robotic Technician program.

Advisory Committee

The advisory committee is made up of representatives from industry and education. Included on the committee are individuals from:

University of Minnesota Robotics Lab
Honeywell Production Technology Lab
Veritechnology
Edutec, Inc.
Compuscribe, Inc.
Rhino Robots
Dept. of Mechanical Engineering-Univ. of Minnesota

The Program

The content of the program is focused on "applications" of theory. In fact, projects completed in the lab have already been utilized in industry (robots were modified for Ford plants), and on the space shuttle. These are the types of projects that are encouraged as students progress through the training program. Half of the student's time is spent in formal lectures and half of the time is spent in labs where students are trained in computer systems, electronics,and mechanical skills. The program is structured as a full-time program which lasts for 22 months, seven hours/day. The areas of competence attained by all graduates include:

A. Install Robot

B. Maintain & Calibrate Robot

C. Operate Robot

D. Plan Specific Robot Task with Engineering Management

E. Implement Specific Robot Task

F. Interface Robot to External System

G. Diagnose Robot Electrical Power System

H. Diagnose Robot Computer Control

I. Diagnose Robot Computer Peripherals

J. Diagnose Robot Mechanical Manipulator

K. Diagnose Robot Hydraulic System

L. Diagnose Robot Sensors

M. Diagnose Communications & Interface Equipment

N. Diagnose Robot's Operative Program

O. Repair Robot Electrical Power System

P. Repair Robot Computer Control

Q. Repair Robot Computer Peripherals

R. Repair Robot Mechanical Manipulator

S. Repair Robot Hydraulic System

T. Repair Robot Sensors

U. Repair Communications & Interface Equipment

V. Correct Robot's Operative Program

W. Safety in Robotics

X. Social Issues of Robotics

Those break down into the following tasks

TASK LIST

A. Area of Competence: Install Robot

01. Check for Shipping Damage and Follow-up
02. Verify Bill of Lading & Handle Miss-Shipments
03. Install Mechanical Components
04. Order & Supervise Power Connection
05. Install & Connect Sensors
06. Install & Connect Control Computer
07. Run Diagnostic Tests & Routines
08. Verify System Integrity & Operation

B. Area of Competence: Maintain & Calibrate Robot

01. Clean Exterior Parts
02. Lubricate Mechanical Drive Train
03. Clean Filters & Fill Hydraulic System
04. Clean Electrical Contacts
05. Check for Abnormal Wear
06. Calibrate Position Servo System
07. Adjust Mechanical Drive Train

C. Area of Competence: Operate Robot

01. Execute Preliminary Check List
02. Power Up Robot
03. Execute Operation Check List
04. Start Robot
05. Verify Proper Operation
06. Stop Robot
07. Effect Power Down Procedure

D. Area of Competence: Plan Specific Robot Task with Engineering Management

01. Establish Task Goal
02. Outline Method & Algorithms to Achieve Task
03. Evaluate Mechanical Motion & Dynamics
04. Define Sensory Requirements & Choose Sensors
05. Define Gripper Requirements & Select Gripper
06. Define Parts Presentation Equipment
07. Evaluate Motion Timing Constraints
08. Evaluate Implementation Time & Resource Requirements
09. Submit to Management for Review & Approval
10. Schedule Task Implementation

E. Area of Competence: Implement Specific Robot Task

01. Order Grippers, Sensors & Related Equipment
02. Install Custom Gripper
03. Install Parts Presentation Equipment
04. Install Sensors
05. Calibrate System
06. Program Specific Task
07. Test, Evaluate & Debug Equipment & Program

F. Area of Competence: Interface Robot to External System

01. Shield Cables
02. Verify Proper Grounding
03. Interface Limit Switches to Robot Controller
04. Interface AC Power Signals to Robot Controller
05. Interface DC Signals to Robot Controller
06. Interface Robot Control Signals to Power Relays

G. Area of Competence: Diagnose Robot Electrical Power System

01. Diagnose Fuse or Relay Failure
02. Diagnose AC or DC Power Supply Failure
03. Diagnose Electric Motor Failure
04. Diagnose Electrical Wiring Failure
05. Diagnose Electrical Servo Operation

H. Area of Competence: Diagnose Robot Control Computer

01. Evaluate User Complaint
02. Interview User
03. Test for Power & Proper Voltages
04. Run Diagnostic Tests for Microprocessor & Bus
05. Run Diagnostic Tests for Memory Operation
06. Run Diagnostic Tests for I/O Ports & Components

    .01 Test serial I/O components
    .02 Test parallel I/O components
    .03 Test connector continuity

07. Run Diagnostic Tests for Video Circuitry
08. Run Diagnostic Tests for Sound Generator

I. Area of Competence: Diagnose Robot Computer Peripherals

- 01. Diagnose Problem to Monitors
  - .01 Test for monitor operation
  - .02 Test for proper installation
  - .03 Test for incoming video signal
  - .04 Check picture quality & convergence
- 02. Diagnose Problem to Keyboard
  - .01 Test keyboard operation
  - .02 Test cables & connections
- 03. Diagnose Problem to Data Cassettes & Cartridges
  - .01 Test for power & motor operation
  - .02 Test cables & connections
- 04. Diagnose Problem to Floppy Disk Drives
  - .01 Test for power & motor operation
  - .02 Test switches & connections
  - .03 Test motor speed & belt tension
  - .04 Test read/write with test diskette
  - .05 Test accessing of tracks
  - .06 Test head alignment

J. Area of Competence: Diagnose Robot Mechanical Manipulator

- 01. Diagnose Abnormal Bearing Wear or Failure
- 02. Diagnose Abnormal Gear Wear or Failure
- 03. Diagnose Abnormal Chain, Belt or Wire Wear or Failure
- 04. Diagnose Mechanical Manipulator Deformation or Fatigue

K. Area of Competence: Diagnose Robot Hydraulic System

- 01. Diagnose Source of Hydraulic Fluid Loss
- 02. Diagnose Fluid Contamination & Sources
- 03. Diagnose Hydraulic Motor & Pump Failure
- 04. Diagnose Hydraulic Servo Valve Failure
- 05. Diagnose Abnormal Wear or Failure of Hydraulic Hoses
- 06. Diagnose Pressure Sensor Failure
- 07. Diagnose Cause of Abnormal Hydraulic Noise & Vibration
- 08. Diagnose Hydraulic Servo System Failure

L. Area of Competence: Diagnose Robot Sensors

01. Diagnose Synchro Position Sensor Failure
02. Diagnose Optical & Potentiometer Position Encoders
03. Diagnose LVDT, Capacitance, Eddy Current Position Sensors
04. Diagnose Force Sensors Failure
05. Diagnose Photo Sensor & Switch Failures
06. Diagnose Video Camera Failures
07. Diagnose Sonar Position Sensors

M. Area of Competence: Diagnose Communications & Interface Equipment

01. Check for Proper Installation
02. Test for Continuity of All Lines
03. Check Terminations
04. Check Switches
05. Test for Power & Proper Installation
06. Test Switches & Connections
07. Test All Optional Features

N. Area of Competence: Diagnose Robot's Operative Program

01. Locate Logical Flaws in Program
02. Locate Parametric Errors in Program

O. Area of Competence: Repair Robot Electrical Power System

01. Replace Fuse and/or Fuse Holder
02. Adjust Voltage Levels
03. Replace Failed Components
04. Replace Power Supply

P. Area of Competence: Repair Robot Control Computer

01. Repair Power Supply Related Problems

    .01 Replace fuse and/or fuse holder
    .02 Adjust voltage levels
    .03 Replace failed components
    .04 Replace power supply

02. Repair Microprocessor & Bus

    .01 Replace clock related components
    .02 Replace reset related components
    .03 Replace microprocessor

P. Area of Competence: Repair Robot Control Computer (continued)

03. Repair Memory Components

- .01 Replace memory board
- .02 Replace memory components
- .03 Replace address decoding & support chips

04. Repair I/O Ports & Components

- .01 Replace I/O components
- .02 Clean connectors
- .03 Replace connectors

05. Repair Video Circuitry

- .01 Adjust RF level
- .02 Adjust color levels
- .03 Replace components

06. Repair Sound Generators

- .01 Repair sound synthesis circuitry
- .02 Repair amplification circuitry
- .03 Replace speaker

Q. Area of Competence: Repair Robot Computer Peripherals

01. Repair Monitor

- .01 Repair high voltage power supply
- .02 Repair horizontal & vertical sweep circuitry
- .03 Repair automatic gain control circuitry
- .04 Replace CRT

02. Repair Keyboard

- .01 Clean key closure contacts
- .02 Replace broken or sticking keys
- .03 Repair/replace cord or connector

03. Repair Digitizers & Joysticks

- .01 Clean or replace contacts & cables
- .02 Repair circuitry

Q. Area of Competence: Repair Robot Computer Peripherals (continued)

- 04. Repair Data Cassettes & Cartridges
    - .01 Repair power supply
    - .02 Clean or repair drive components
    - .03 Clean or repair read/write head & associated electronics
    - .04 Clean or replace switches & connectors
    - .05 Adjust or repair speed control circuitry
- 05. Repair Floppy Disk Drives
    - .01 Repair power supply
    - .02 Clean or repair drive components
    - .03 Clean or repair read/write head & associated electronics
    - .04 Clean or replace switches & connectors
    - .05 Adjust or repair speed control circuitry
    - .06 Adjust or repair head motion components
    - .07 Adjust head alignment

R. Area of Competence: Repair Robot Mechanical Manipulator

- 01. Replace Worn or Failed Bearings
- 02. Replace Worn or Failed Gears
- 03. Replace or Adjust Worn or Failed Chains, Belts, or Wires
- 04. Align, Adjust or Replace Mechanical Manipulator Parts

S. Area of Competence: Repair Robot Hydraulic System

- 01. Clean or Replace Hydraulic Fluid
- 02. Replace O-Rings, Gaskets & Filters
- 03. Repair or Replace Hydraulic Motors & Pumps
- 04. Repair or Replace Hydraulic Servo Valve
- 05. Replace Worn or Failed Hydraulic Hoses
- 06. Calibrate or Replace Pressure Sensors
- 07. Adjust or Repair Hydraulic Servo System

T. Area of Competence: Repair Robot Sensors

- 01. Repair Synchro Position Sensor Failure
- 02. Repair Optical & Potentiometer Position Encoders
- 03. Repair LVDT, Capacitance, Eddy Current Position Sensors
- 04. Repair Force Sensors Failure
- 05. Repair Photo Sensor & Switch Failures
- 06. Repair Video Camera Failures
- 07. Repair Sonar Position Sensors

U. Area of Competence: Repair Communications & Interface Equipment

01. Clean or Replace Connectors
02. Clean or Replace Switches
03. Repair or Replace Cables
04. Splice Fiber Optic Cables & Terminators
05. Replace Photoelectronic Components
06. Replace Modems & Multiplexers
07. Replace Solid State Relays & Power Electronics
08. Analog to Digital and Digital to Analog Components

V. Area of Competence: Correct Robot's Operative Program

01. Correct Logical Errors in Program
02. Correct Parameters in Program

W. Area of Competence: Safety in Robotics

01. Create & Maintain a Safe Environment

    .01 Identify & use proper procedures of AC power
    .02 Identify & use proper procedures for hydraulics
    .03 Identify & use proper procedures for mechanical drives

02. Exclude People from Robot's Work Space

    .01 Install physical barriers
    .02 Install electrical interconnects
    .03 Install sonic or photo detection methods

X. Area of Competence: Social Issues of Robotics

01. Demonstrate Robot to Management
02. Explain Implications of Robotics to Other Workers
03. Facilitate Acceptance of Robot by Workforce

This document was developed by:

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This Task List was developed in August 1982 by the Staples Technical Institute of Staples Minnesota 56479. This document may only be copied with full credit to the authors, the Staples Technical Institute, and the State of Minnesota.

The required courses and their descriptions follow.

Two Year Program Schedule*

Course Description	Credits
RT 101 History of Robotics	1
RT 102 Robotic Fundamentals	5
RT 103 Robotic Theory	5
RT 104 Electronics	15
RT 105 Robotic Computer Control	21
RT 106 Mechanical Aspects of Robotics	10
RT 107 Sensing Devices	9
RT 108 Industrial Robots	1[illegible]
RT 109 Robotic Maintenance and Repair	12
RT 110 Safety	2
RT 111 Future Trends in Robotic Technology	9
RT 112 Laboratory Applications	34

Total	134

*Program is Competency Based

RT 101 HISTORY OF ROBOTICS: The history of early robotics from the 18th century is reviewed. Included is robotic technology advancement into the current industrial applications.

RT 102 ROBOTIC FUNDAMENTALS: This course involves components, teminology and robotic classifications taught in the classroom and laboratory.

RT 103 ROBOTIC THEORY: An overview of the interacting technologies which compose robotic theory. Dimensions and space calculation and application to mechanical movement.

RT 104 ELECTRONICS: DC, AC circuitry, active devices, standard conductors, solid state electronics.

RT 105 ROBOTIC COMPUTER CONTROL: This part of the program is divided into a number of smaller course sections in order to cover the high technological areas and to give it the importance that is required in the robotics field:

I. Microprocessor Fundamentals: Terminology, Micro-computer literacy, computer languages, number systems and other microprocessor fundamentals.
II. Introduction to Programming: Beginning conditional branching, algorithms and additional instruction centering in the programming of robotic controls.
III. Control Interfacing with Devices: Classroom and laboratory study of the sequencing for interfacing with peripheral and sensing devices.

RT 106 MECHANICAL ASPECTS OF ROBOTICS: Understanding and applying the mechanical components of robotics and interfacing it with manufacturing environment.

RT 107 SENSING DEVICES: Optical, ultrasonic, distance measuring, sound, audio, voice, video, tactal, time and other sensing devices are studied and applied in the classroom and laboratory.

RT 108 INDUSTRIAL ROBOTS: Various manufacturer's robot specifications and applications in industry are studied and applied in laboratory.

RT 109: ROBOTIC MAINTENANCE AND REPAIR: Studying and practicing trouble-shooting, repair and maintenance, and keeping systems on line. Multi-industrial applications in various environments are included.

RT 110 SAFETY: Procedures and guidelines for the maintenance of a safe environment.

RT 111 FUTURE TRENDS IN ROBOTIC TECHNOLOGY: Fiber optics, lasers, tactal sensing, artificial intelligence and other developmental areas are studied.

RT 112 LAB APPLICATION EXPERIMENT: Class experiments in robotic application are completed as a part of this course. The purpose of this exercise is to apply the program's content in a practical setting.

Equipment

Labs are arranged so that there are generally two people per computer. $30,000 worth of Apple IIe's were ordered for the lab in addition to $20,000 worth of equipment for the electronics lab and $10,000 worth of oscilliscopes. Equipment purchased for the program includes:

10	Microprocessor Trainers
10	Instruction Robot ET 1 Units
1	Automatic Robavision
1	GMF S360R Robot
1	AID 800 Robot (Automatic Robavision) with Lincoln Welder
2	Hero 1 Educational Robots
1	GCA 6100 XR (Overhead Gantry Robot)
1	GCA F200 Controller
1	GCA B200 Controller
1	GCA P300-H Robot
1	GCA P300-V Robot
1	Overhead Conveyor with Microprocessor

Faculty

A new faculty member was hired specifically for this program. He has an electronics background with the military and has worked with computers for 12 years. He has done assembly line work and owned his own computer repair business.

Placement

A class has not graduated from the program yet industry representatives have already expressed interest in hiring the graduates. The "applications theme" which is apparent throughout the program has resulted in industry contact throughout the course work. Students are working on real problems throughout their program and thus in tune with what is happening in industry and manufacturing.

Information Processing

Automated office technicians are those workers who usually have a background in secretarial science, office management or office machines including a working knowledge of computers and business communications (Florida Survey, 1983). Employees can be engaged in electronic word processing, record keeping and communications using computer based systems, such as electronic filing and mail systems, in addition to the standard responsibilities of clerical and secretarial workers.

The handling of information in the office usually involves six phases: capture, creation, manipulation, distribution, storage and retrieval. Technologically-based systems have been developed to expedite the processing of information in each of these phases. These systems include word processing, data processing, micrographics, and reprographics. (D'Onofrio,1983).

A consequence of these technological changes is the changing responsibilities of office personnel. New skills and knowledge are needed in order to complete work tasks. Educational institutions need to assess how they can best prepare students for work in an office setting which is dominated by new technology.

Presently, single disciplines do not exist which address all the skills needed by individuals who will work in an office. In general, employers have leaned on vendors to train personnel. Vocational programs, however, should be responsible for training students to function as information processors because employers will quickly tire of retraining new employees. This training should include word processing, data processing and the ability to conceptualize the total business information system (D'Onofrio, 1983). Many routine jobs will be performed automatically through information systems, so the higher cognitive levels of application and evaluation will need to be developed during vocational training programs, i.e., students will need to not only know how a particular word processing package operates but also how it can be integrated with data processing concepts to set up an efficient, automated office. Students will also need to know how to develop, use, and manage a data base on a microcomputer with a greater understanding than simple mastery of mechanical skills. In sum, they will need to utilize the capabilities and take into account the limitations of the systems.

Although it is easy to envision what a traditional office might look like with computerized work stations, it is important for educators to acknowledge that the skills learned in their programs will also be applied in less traditional work settings. For example, a small company in Staten Island, New York uses integrated data management and information processing programs to draft the playing schedules of the American and National baseball leagues, the National Basketbell Association and both the indoor and outdoor soccer leagues. In doing so, information is not only mechanically entered but it also has to be structured to fit both the computer and human needs, e.g., each team needs its share of home games, rest days and travel time; the Red Sox want to play at home every Patriot's Day but not on Mother's Day; Canadians want homegames on their national holidays; the Yankees want away games on Jewish holidays (Shell, 1983).

The company needs to schedule a total of 3565 games for the four leagues. Their biggest problem is the inability of the computer to cope with the inconsistencies inherent in the schedule. The solution requires a broad cognitive understanding of data system. They decided the best solution was to pencil in the "exceptional" categories. The company then wrote a program with which they can actually interact.

Although the "typical" automated office technician will not necessarily need to write a program, this example illustrates the types of problems that those working with a data base system will confront. The technician will need to troubleshoot by either solving problems or knowing who to contact to solve the problems inherent in any information system.

An example of a data processing curriculum follows.

References

D'Onofrio, Marianne "The Office - Today and Tomorrow" in Microcomputers: Applications in Vocational Education Edited by Rodenstein, J. and Lambert, R. Madison, Wisconsin: University of Wisconsin, Vocational Studies Center 1983

Florida Council for High Technology and Industry High Technology Survey 1983

Shell, Ellen Ruppel The Home Team Technology Illustrated Volume 3 (8) August 1983 pp. 49-50,52

PROGRAM: Data Processing Technology
INSTITUTION: Itawamba Junior College
653 Eason Boulevard
Tupelo, Mississippi 38801
(601) 842-5621
CONTACT PERSON: Charles Chrestman
DEGREE: Associate Degree - 2 Year Program
DATE BEGAN: 1966

History

The Itawamba Junior College Data Processing Technology Program started in 1966 as an eleven month vocational program. Initially, approximately twenty students were selected through a screening procedure for enrollment in the program. The screening procedure measured student aptitude done with an IBM aptitude test and an approved Itawamba Junior College aptitude test.

Inital instruction focused on key punching and the wiring of control panels for an IBM 402.

In December, 1966, the college acquired an IBM 360 Model 30 Computer for training. It was then possible to introduce the students to RFG programming for the first time. This practice still continues today. The IBM 360 remained in use until 1978. It was then replaced by an IBM System 3 Model 12. This machine gave the college its first capability to extend the program languages offered to COBOL and Fortran.

Presently, the college is replacing the old IBM System 3 with a newer IBM System 38 with the on-line capability of the newer computers.

The Program

The Date Processing Technology program is a two-year, four semester program. The courses taken and semester hours earned are listed below.

DATA PROCESSING TECHNOLOGY

(Tupelo Campus)

First year	First Semester	Semester Hours
TDP 1113	Intro. To Data Processing	3
TDP 1126	RPG Programming I	6
ENG 1113	English Composition I	3
BAD 1313	Business Mathematics	3
TAC 1213	Accounting	3
	Total	18

First Year	Second Semester	Semester Hours
TDP 1136	RPG Programming II	6
TEG 1123	Technical Communications	3
TAC 1223	Accounting II	3
TDP 1213	Operational Control Language	3
TDP 1313	Microcomputer Concepts -or-	
TBU 1613	Word Processing Concepts	3
		Total 18

Second Year	First Semester	Semester Hours
TDP 2416	COBOL Programming I	6
TDP 2146	Advanced RPG Programming	6
SPT 1113	Oral Communications	3
MAT 1233	Intermediate Algebra	3
		Total 18

Second Year	Second Semester	Semster Hours
TDP 2426	COBOL Programming II	6
TDP 2156	System Analysis & Design	6
TDP 2516	Work Experience or	
*Approved Elective		6
		Total 18

*Electives to be approved by program advisor.

(Much of the curriculum is currently under revision due to the purchase of the new computer.)

DATA PROCESSEING TECHNOLOGY
COURSE DESCRIPTIONS

TDP 1113 INTRODUCTION TO DATA PROCESSING. This course introduces the student to entering, updating, and verifying data using IBM data entry machines. Emphasis is placed on adding, deleting, and changing records on the diskette and using multiple data sets. Two hours lecture, two hours lab credit, three semester hours.

TDP 1126 RPG PROGRAMMING I. This course is designed to teach the student how to write programs using the RPG programming language. Topics covered include input/output processing, arithmetic codes, comparing, control levels, fetch overflow, multiple record types, and exception output. Three hours lecture, six hours lab. Credit, six semester hours.

TDP 1136 RPG PROGRAMMING II. This course is a continuation of RPG Programming I. Topics covered include, table/array processing, chaining, and subroutines. Three hours lecture, six hours lab. Credit, six semester hours.

TDP 2156 SYSTEM ANALYSIS AND DESIGN. This course is designed to show students how all business functions interrelate by requiring students to analyze manual procedures, design a sound systems approach, and implement an assigned project. Three hours lecture, six hours lab. Credit, six semester hours.

TDP 1213 CONTROL LANGUAGE PROGRAMMING. This is a course of study designed to provide the student with the opportunity to use the control language functions. Included are expanded parameters, expressions, cpf functions and object types, control language syntax, commands and descriptions, monitored error messages, and files used by CL commands. Three hours lecture. Credit, three semester hours.

TDP 2416 COBOL PROGRAMMING I. A study of design and implementation of structured programs using COBOL. Topics presented are computation, report editing, control breaks and table processing. Emphasis will be placed on the solution of a wide variety of problems occurring in the business environment. Three hours lecture, six hours lab. Credit, six semester hours. Pre-requisite: TDP 1136.

TDP 2426 COBOL PROGRAMMING II. A continuation of COBOL Programming I with emphasis on advanced application of files. Topics included are sorting, searching, and elementary database concepts. Three hours lecture, six hours lab. Credit, six semester hours. Pre-requisite: TDP 2416.

TDP 2516 WORK EXPERIENCE. A cooperative program between industry and education which integrates the students technical studies with live data processing work experience. Eighteen (18) hours minimum per week. Credit, six semester hours.

TDP 1313 MICROCOMPUTER CONCEPTS. This course introduces the student to the microcomputer and teaches the proper and correct ways to design and write Basic programs. Two hours lecture, two hours lab. Credit, three semester hours.

TDP 1323 BASIC PROGRAMMING. This course is designed to provide a foundation in structured BASIC programming. Topics to be covered are interactive program design, table handling, sequential files and random access files. Two hours lecture, two hours lab. Credit, three semester hours. Prerequisite: Competence in at least one computer language.

Current teaching techniques rely on lecture and laboratory class sessions. The ratio between the two is approximately 1:2 respectfully. The college believes that the laboratory sessions are the most productive times within the learning experience. It permits teacher-student interaction on assignments which replicate those found in the work place.

The last semester of the student's training consists of a Work Experience course where the student is placed in a Data Processing shop for OJT experiences. This placement is oftentimes with compensation but that is not a requirement.

Current curricula requirements expose students to other occupational program areas which tends to broaden their knowledge base for the transition from student to employee.

Faculty

The Itawamba Junior College program started with one instructor in 1966. He had been the Data Processing manager for a local business for ten years. In 1967, the program grew to the point where a second instructor was required. The individual had a similar background.

In 1978, another faculty member was employed after working part-time for a local sheriff's department and the college. Increases in enrollment in the 1980's has necessitated the addition of a fourth faculty member whose background is in mathematics and computer science. All the original faculty are still with the college.

Placement

Itawamba Jnuior College has placed 87.5% of its Data Processing Technology graduates in jobs related to the Data Processing field.

MISCELLANEOUS

PROGRAM: Technical Writing Program
INSTITUION: Middlesex Community College
Springs Road
Bedford, Massachusetts 01730
(617)275-8910
CONTACT PERSON: Caryl Dundorf
DEGREE: Certificate of Completion (after 20 week course)
DATE PROGRAM BEGAN: Fall 1982

History

The Technical Writing Program was designed in cooperation with the Division of Occupational Education in the Massachusetts Department of Education and the Massachusetts High Technology Council. Representatives from the high tech industries helped develop the curriculum and many of them continue to serve on an advisory committee. The program was originally developed to retrain teachers who were laid off due to budget constraints. Although State Funding provided tuition for this re-training program initially, the program has recently become self-supporting.

Advisory Committee

Professionals from the high tech industries and related fields serve on the Advisory Committee. They have developed, guided and evaluated the focus of the program since it began. They meet 4-5 times during the 5-month program. Their experience and direction insures focus on the skills most valued in the industry today. They include respresentatives from:

Data General, Software Documentation Division
Honeywell, Inc. Technical Publication
Massachusetts High Technology Council
Digital Equipment Corportaion, Software Publications
Prime Computer, Inc. Technical Publications
Wang Labs. Inc. Technical Publications
NEC Information Systems Inc. Publications
Massachusetts Teachers Assocationa, Director of Research

The Program

The Technical Writing Program is a 20 week course that incorporates technical writing and the fundamentals of computer programming along with Management Skills and Word Procesing modules.

The Technical Writing portion of the course involves 10 hours of instruction per week and includes topics such as:

Types of Computer Systems
Data Storage
Types of Documentation
Critiquing Documentation

Using the Text Editor
Processing in Data
Data Organization
Types of Audiences
Using the Computer
Production and Design
Writing Software Documentation
Revising Existing Documentation

The software portion of the program involves 10 hours of instruction per week. Some of the topics included are:

Introduction to Computers
Operating Systems
Networking
BASIC-PLUS
Data Organization
Data Communications
PDP-11 Assembly Language
COBOL

In addition to the 20 hours of class time each week, the students have another 10 hours per week on the terminal. This allows them the opportunity to test what they have learned in class, print out written assignments, and become familiar with the general functioning and capacity of the computer. Word Processing training and an Interpersonal Skills module which focuses on time-management, interviewing and negotiating skills complete the program.

The Technical Writing Curriculum and Software Curriculum follow.

TECHNICAL WRITING CURRICULUM *

SOFTWARE CURRICULUM *

III

MIDDLESEX COMMUNITY COLLEGE
SPRINGS ROAD
BEDFORD, MA 01730

* Curriculum is subject to change.

Caryl Dundorf, Coordinator
Telephone: 275-8910 Ext. 278 or 277

February 14, 1983

TECHNICAL WRITING CURRICULUM

TEXTS:

Clear Technical Writing, by John Brogan, McGraw-Hill

Elements of Style, by Strunk and White, MacMillan

Technical Communications, by Anne Eisenberg, McGraw-Hill

WEEK 1:

SURVEY OF SOFTWARE TECHNICAL WRITING	MON.	Technical writing/software technical writing
	TUES.	Different types of technical writing
	WED.	Goals, styles and audiences
	THURS.	Typical problems with documentation

ASSIGNMENTS: Exercises from text, editing each other's work

WEEK 2:

WRITING FUNDAMENTALS	MON.	Principles of technical writing
	TUES.	Grammar and punctuation review
	WED.	Grammar and punctuation review
	THURS.	Sentence format, paragraphing, verb tense and voice

ASSIGNMENTS: Describe the physical parts of a computer system.

WEEK 3:

SOFTWARE TOOLS FOR WRITERS - I LEARNING TO USE EDT	MON.	Editing Concepts - creating, modifying text
	TUES.	EDT Concepts - Files, lines, characters
	WED.	Getting started with EDT - "EDT," line pointer, text display, line numbering, exit
	THURS.	EDT commands - Insert, delete, substitute, replace, CTRL/Z, resequence, %WH

ASSIGNMENTS: Chapters from text; assigned exercises
Write the definition of an algorithm

WEEK 4:

ADVANCED EDT FEATURES	MON.	Keypad editing (VT-100)
	TUES.	Moving the cursor - Arrows, direction, entity, buffer
	WED.	Deleting, inserting, replacing text
	THURS.	Cut and paste; special functions

ASSIGNMENTS: Chapters from text; assigned exercises
Write instructions for converting decimal numbers to binary.

TECHNICAL WRITING CURRICULUM (Continued)

WEEK 5:

RUNOFF LECTURES	MON.	Runoff concepts - format, justification, spacing, headers, hyphenation
	TUES.	Input/output - source file, formatted file; command line, options and their effects
	WED.	Runoff text formatting commands
	THURS.	Runoff page formatting commands

ASSIGNMENTS: Review chapters. Define computer instructions; describe how the CPU executes the instructions. Use EDT and Runoff to prepare text.

WEEK 6:

ACHIEVING AN EFFECTIVE STYLE - I	MON.	Method: plan, research, write, revise
	TUES.	Problem statement: Beginner's Guide for either EDT or RUNOFF
	WED.	Approach to research
	THURS.	Outlining the manual

ASSIGNMENTS: Method: Reading and exercises from text.
Describe BASIC-PLUS string manipulation
Write rough outline of 1st major manual.

WEEK 7:

ACHIEVING AN EFFECTIVE STYLE - II	MON.	Refining outline: audience and organization
	TUES.	Deciding on a format
	WED.	Beginning to write; how and where to start; false starts; "writer's block"
	THURS.	Writing first draft

ASSIGNMENTS: Format: Reading and exercises from text.
Write first draft of 1st major manual.

WEEK 8:

ACHIEVING AN EFFECTIVE STYLE - III	MON.	Revising
	TUES.	Review of elements of style
	WED.	Mini-Clinic: formatting
	THURS.	Mini-Clinic: revising

ASSIGNMENTS: Style: Reading and exercises from text.
Complete first draft of 1st major manual.

TECHNICAL WRITING CURRICULUM (Continued)

WEEK 9:

PARTS OF A MANUAL/ PLANNING	MON.	Parts of a manual; develop class standard
	TUES.	Front and back matter; Index and Table of Contents
	WED.	Making indexes useful
	THURS.	How to write a documentation plan

ASSIGNMENTS: Describe the class style standards for the parts of a manual.
Index first manual.

WEEK 10:

START SECOND MANUAL: RESEARCH	MON.	Functional specs.; uses; comparison with end-user documentation
	TUES.	The programmer interview
	WED.	Write functional specifications and Instructor's critique
	THURS.	Revise functional specifications

ASSIGNMENTS: Begin documentation plan based on functional specifications and interviews.

WEEK 11:

DOCUMENT PLANNING	MON.	What is a document plan?
	TUES.	Planning the schedule; time estimates
	WED.	Reviewing the doc plan
	THURS.	Committing to the schedule

ASSIGNMENTS: Write documentation plan.
Begin first draft of manual.

WEEK 12:

FIRST DRAFT PROCESS:	MON.	The developer interview
	TUES.	Getting started: 'writer's block," false starts
	WED.	The writing sequence; modifying the outline
	THURS.	First draft review; preview

ASSIGNMENTS: Work on first draft of manual.

TECHNICAL WRITING CURRICULUM (Continued)

WEEK 13:

REVIEW PROCESS - I	MON.	First draft review; scope, content, parallel vs. serial
	TUES.	Conducting a review meeting
	WED.	Technical reviewing; validating review comments: Review meeting simulation, Groups A/B Review meeting simulation, Groups C/D
	THURS.	Coping with hostile or misguided reviewers

ASSIGNMENTS: Finish first draft.

WEEK 14:

REVIEW PROCESS - II	MON.	Review drafts - Gp A
	TUES.	Review drafts - Gp B
	WED.	Review drafts - Gp C
	THURS.	Review drafts - Gp D

ASSIGNMENTS: Conduct reviews; role playing.

WEEK 15:

FINAL DRAFT PROCESS	MON.	Final draft review; signoff
	TUES.	Incorporating final review comments
	WED.	Indexing: techniques; using automated indexing tools
	THURS.	Proofreading; standard proofreader's marks

ASSIGNMENTS: Begin final draft of manual.

WEEK 16:

FINAL INTEGRATION OF MANUAL	MON.	Covers, "boilerplate," index, reader's comments
	TUES.	Assembling repro package
	WED.	Final copyread, checklist
	THURS.	Including graphics/examples

ASSIGNMENTS: Continue final draft preparation.

WEEK 17:

TECHNICAL EDITING - LITERARY	MON.	The editing function: overview
	TUES.	Elements: structure, organization, style, grammar
	WED.	Degrees of editing: cursory to rewrite
	THURS.	Writer/editor relationship

ASSIGNMENTS: Apply standard editing marks to selected writing samples.

TECHNICAL WRITING CURRICULUM (Continued)

WEEK 18:

TECHNICAL EDITING - PRODUCTION	MON.	The writer/production interface: editor's role; how writers can help themselves
	TUES.	Planning the production process
	WED.	Managing the production process
	THURS.	Details of production editing: widows, page breaks, tables, figures.

ASSIGNMENTS: Edit classmate's manual.

WEEK 19:

PRODUCTION, PRINTING TECHNIQUES - I	MON.	Producing repro: typewritten, word processing
	TUES.	Computerized output: DIABLO
	WED.	Computerized output: typeset/typefaces
	THURS.	Tour Production Department

ASSIGNMENTS: Open

WEEK 20:

PRODUCTION, PRINTING TECHNIQUES - II	MON.	History of printing: current methods
	TUES.	Inks, paper, etc.
	WED.	Binding. Class wrap-up
	THURS.	Tour of a print shop

ASSIGNMENTS: Open

SOFTWARE CURRICULUM

TEXTS:

Understanding Computer Science, by Roger S. Walker, Radio Shack, 1981

Assembly Language for the PDP-11, By C. Kapps & R.L. Stafford, Prindle, Weber & Schmidt, 1981

BASIC-PLUS Language Manual, DEC, December 1981

Introduction To Computer Programming, ANSI-COBOL, By Shelly & Cashman, Anaheim Publishers

RSTS/E System User's Guide, DEC, December 1981

WEEK 1:

COMPUTER ARCHITECTURE & HARDWARE	MON.	History & Components of Computer Systems
	TUES.	Binary Arithmetic & Representation of Data
	WED.	Logical & Arithmetic operations
	THURS.	Memory & Auxiliary Storage Devices

ASSIGNMENTS: WALKER, CH. 1 & 2
LOGIN to RSTS, use of EDT

WEEK 2:

INTRO. TO PROGRAMMING	MON.	Steps in Software Development: Flowcharts and Specifications; Top-down design
	TUES.	Program Control: elementary structures
	WED.	Program Coding
	THURS.	Program Execution & Intro. to languages

ASSIGNMENTS: WALKER, CH. 3
Reading: "Personal Computers" by Toong & Gupta, Scientific American, Dec. 1982
PROGRAM #1

WEEK 3:

INTRO. TO LANGUAGES & PROGRAMMING IN BASIC-PLUS	MON.	High level languages vs. Assembler language: Function of Compilers & Assemblers
	TUES.	Developing a BASIC-PLUS program under RSTS/E
	WED.	Representing Constants, Variables, and Expressions
	THURS.	Elementary Input/Output

ASSIGNMENTS: WALKER, CH. 4
BASIC-PLUS, CH. 1-5, 7-8
PROGRAM #2

SOFTWARE CURRICULUM (Continued)

WEEK 4:

BASIC-PLUS	MON.	Flow control statements
BRANCHES, LOOPS,	TUES.	Using arrays
SUBSCRIPTED VARIABLES	WED.	Subroutines
SUBROUTINES	THURS.	Strings & string functions

ASSIGNMENTS: BASIC-PLUS, CH. 9
PROGRAM #3

WEEK 5:

ADVANCED	MON.	String input & output
BASIC-PLUS	TUES.	Integer, Floating-Point and logical operations
FEATURES	WED.	Matrix Manipulation
	THURS.	File processing

ASSIGNMENTS: BASIC-PLUS, CH. 11-14
PROGRAM #4

WEEK 6:

OPERATING	MON.	History & Types of Operating Systems
SYSTEMS	TUES.	JOB management algorithms
FUNCTIONS	WED.	Input/Output management
	THURS.	Memory Management

ASSIGNMENTS: WALKER, CH. 5-6
RSTS/E as case study

WEEK 7:

OPERATING	MON.	Executive Functions & Programs
SYSTEMS	TUES.	File Management Programs
SOFTWARE	WED.	Program Development Tools
	THURS.	Utilities

ASSIGNMENTS: RSTS/E case study
MICRO-Processor operating
Systems: case study

WEEK 8:

DATA	MON.	Elements of a Data Base
STRUCTURES	TUES.	Stacks, Queues, Lined Lists, Trees
	WED.	Sorting and Searching
	THURS.	Hashing and Indexing

ASSIGNMENTS: WALKER, CH. 7
PROGRAM #5

SOFTWARE CURRICULUM (Continued)

WEEK 9:

MACHINE & ASSEMBLY LANGUAGE I	MON.	Language Translators
	TUES.	Machine Language Programming
	WED.	The Assembly Process
	THURS.	An elementary instruction set

ASSIGNMENTS: WALKER, CH. 8
KAPPS & STAFFORD, CH. 1-3

WEEK 10:

ASSEMBLY LANGUAGE II	MON.	Memory and Registers
	TUES.	Instruction Formats & Mnemonics
	WED.	Program Control Features
	THURS.	Laboratory-editing, Assembling, Linking, executing programs

ASSIGNMENTS: KAPPS & STAFFORD, CH. 4-5
PROGRAM #6

WEEK 11:

ASSEMBLY LANGUAGE III	MON.	PDF-11 Arithmetic
	TUES.	- - Signed, Unsigned numbers
	WED.	- - Multiplication & Division
	THURS.	- - Multiple Precision

ASSIGNMENTS: KAPPS & STAFFORD, CH. 6
PROGRAM #7

WEEK 12:

ASSEMBLY LANGUAGE IV	MON.	Addressing modes and Instruction formats
	TUES.	Indirect Addressing
	WED.	Indexed Addressing
	THURS.	Deferred Addressing

ASSIGNMENTS: Array Processing
PROGRAM #8

WEEK 13:

COMMUNICATIONS & NETWORKING I	MON.	Asynchronous Communications - - Devices & Protocols
	TUES.	Polling & Multiplexing
	WED.	Synchronous Communications - - Devices & Protocols
	THURS.	Standard IBM Protocols: BISYNC, SDLC

ASSIGNMENTS: Readings from McNamara, Technical Aspects of Data Communications

SOFTWARE CURRICULUM (Continued)

WEEK 14:

COMMUNICATIONS & NETWORKING II	MON.	Centralized Networks: Layered Architecture
	TUES.	Case Study - SNA I
	WED.	Case Study - SNA II
	THURS.	Case Study - SNA III

ASSIGNMENTS: Readings in IBM Technical Documentation

WEEK 15:

COBOL I	MON.	Introduction to COBOL
	TUES.	COBOL Program Divisions
	WED.	Designing a COBOL Program
	THURS.	Examples and Exercises

ASSIGNMENTS: Shelly & Cashman, CH. 1-2
Program #9

WEEK 16:

COBOL II	MON.	Arithmetic Operations
	TUES.	Arithmetic Operations
	WED.	Editing & Displaying Reports
	THURS.	Examples and Exercises

ASSIGNMENTS: Shelly & Cashman, CH. 3-5
Program #10

WEEK 17:

COBOL III	MON.	Conditionals and Branching
	TUES.	Subroutines I
	WED.	Subroutines II
	THURS.	Examples & Exercises

ASSIGNMENTS: Shelly & Cashman, CH. 6-10
Program #11

WEEK 18:

COBOL IV	MON.	Table Lookup
	TUES.	Searching
	WED.	Sorting
	THURS.	Advanced Statements

ASSIGNMENTS: Shelly & Cashman, CH. 11-13
Program #12

WEEK 19:

REVIEW & PROGRAMMING PROJECTS

WEEK 20:

REVIEW & PROGRAMMING PROJECTS

MANAGEMENT SKILLS CURRICULUM

Technical Writing III Program

FORMAT: Group discussion/lecture/demonstration, projects, panels, etc. Appropriate handouts will be provided.

CONTENT: The first two sessions will follow the order listed below. The order of the others will be adjusted to fit the needs of the group.

ORIENTATION:

- Expectations: instructor/group
- Planned curriculum, adaptations/additions
- Assessing individual behavior styles
- Change and Stress/Managing the Effects

ORGANIZATIONAL BEHAVIOR:

Discussion/demonstration/group exercises in MBO, MBI, Japanese, etc. Hope the tech writer fits in with each.

THE JOB OF TECH WRITER:

A panel of tech writers/managers to discuss their day to day roles.

The tech writer as knowledge worker: what that means on a day to day basis.

THE TECH WRITER'S BASIC SKILLS:

- Research/information gathering: non-people sources
- Research/information gathering: people sources
  - Negotiating
  - Interviewing
  - Listening
  - Planning, executing, facilitating, following up on effective group and one-to-one meetings.

SELF-MANAGEMENT:

- Some Assumptions about Adult Learners/Workers
- Controlling time/workflow/deadlines/workloads
- Monitoring Quality
- Functioning as a team member/as an autonomous worker

PERSONNEL/EXPECTATIONS:

A guest speaker or panel to discuss salary ranges, benefits, career paths, training, job interviews, resumes, jss methods.

JOB SEEKING SKILLS:

- Where the jobs are/how to get them.
- Resumes/market letters
- Networking/information interviews
- Mastering the job interview-phone/in person

Type of Student

The average student in the program is in their mid 30's. There are approximately equal numbers of males and females in the program. Applicants are required to have a Bachelor's Degree and three to five years of work experience. An intensive screening process involving writing sample, test battery and interviews culminates in the selection of twenty-five qualified candidates.

Equipment

Equipment has generally been provided by the high tech companies who have served on the advisory committee. Equipment used includes:

Digital - PDP 11-34, PDP 11-44 (23 terminals)
WANG - VS-80 where the students are trained on the word processor
NEC - a variety of hardware and software

Faculty

The faculty, hired specifically for the program are professionals working full-time in industry. The Director of Computer Services at the college is closely involved with the program, serving as instructor of the programming module. The Technical Writing module is taught by two technical writers from Digital Equipment Corporation.

Placement

The coordinator of the program takes an active role in contacting companies and informing them about the program. Each student has a portfolio containing projects and writing assignments completed during the 20-week period which are available for hiring companies to review. Companies are encouraged to interview students on campus or at their facilities. To date, three classes have graduated. The overall placement rate is over 98%. Most of the graduates are software writers. Other are hardware writers, editors, or programmers.

Some of the hiring companies include:

Adage	Software/Hardware Writer
Applicon	Software Writer
Atex	Software Writer
Bruce Hall	Programmer
Commercial Union Insurance	Software Writer
Data General	Software Writer
Data Terminal	Software Writer

Digital Equipment	Software Writers and Editors
GTE	Software Writer
Gulf Oil	Trainer
Honeywell	Software/Hardware Writers
Inforex	Software Writers
Kaye Instruments	Hardware Writers
NEC Information Systems, Inc.	Software/Hardware Writers
Prime	Software/Hardware Writers
Raytheon	Hardware Writers
S&S Electronics	Programmer
Wang	Software Writers

PROGRAM: Precision Inspection and
Non-Destructive Examination
INSTITUTION: Northeast Wisconsin Technical Institute
2740 West Mason Street
Green Bay, Wisconsin 54303
(414) 497-3131
CONTACT: John Pogorelc
DEGREE: One Year Vocational Diploma
DATE BEGAN: 1976

Definition

Precision Inspection is the set-up and measurement of parts with both conventional hand tools and electronic instuments to satisfy the dimensional requirements of both the shop and laboratory. These skills can be used in all fields of metrology; as a precision inspector, calibration inspector or inspection technician.

Nondestructive Testing Technicians are responsible for the set-up, operation, and interpretation of penetrant, magnetic particle, eddy current, ultrasonic and radiographic tests. Nondestructive testing includes applications where part failure due to hidden defects could be catastrophic. Occupations include many different industries: aerospace, nuclear power, petro-chemical, transportation, consruction, construction equipment etc.

The program prepares a student for a career in the precision measurement and non-destructive testing. These skills would be adapted to the testing of materials, parts and products so that they conform to the manufacturer's specification and standards and in writing and reporting inspection data for engineering analysis.

Technicians usually work for or closely with the Research and Devlopment, Quality Control and Engineering Departments.

History

In 1976, an advisory committee connected to the trade and industry division encouraged the trade and industry department to offer seminars in non-destructive testing to employees of local industries. The response from industry was very positive. From those seminars, a one-year Vocational Diploma program was developed.(Along with this program there is a two-year quality assurance associate degree program. In this report, only the one-year Precision Inspection and program will be discussed.) Not only were local employers interested in the program but support was expressed by several national societies and associations who encoured Northeast Wisconsin Techncial Institute to pursue formal programs in this carricular

Advisory Committee

On the advisory committee are local industry personnel (managers and line workers) and consultants who work in the non-destructive testing area, in addition to representatives from the National Society of Quality Control and the American Society of Nondestructive Testing.

The Program

Students learn to utilize nondestructive testing methods to locate hidden flaws, cracks and unseen material conditions which might cause a part of a product to fail. These methods include penetrant testing, magnetic particle testing, eddy current testing, ultrasonic testing and radiographic testing.

Graduates of the program will have mastered skills in:

A. Identifying materials and processes in the inspection of products
B. Inspecting parts using precision instruments
C. Interpreting tolerances
D. Interpreting nondestructive test results
E. Demonstrating communication and reporting skills

The program includes 360 hours of instruction in Precision Inspection and Non-Destructive Examination. Other courses in the diploma program include communication skills, math, statistics, blueprint reading, industrial processes, weld inspection, precision inspection and a course in metallurgy where students perform destructive tests and spectrographic analysis of materials.

Prospective students should have basic mathematic skills, mechanical aptitude, manual dexterity, hand-eye control, and must be thorough, precise and innovative. In addition, prospective students should have good vision and be able to grasp basic scientific principles.

The program can accomodate up to 32 students. Generally, two-thirds of the students are recent high school graduates. Approximately 5-6 have just completed other related programs such as welding or machine tool technology and want to add to their skill level. Others are students who are returning to school after working for a period of time.

The program is designed for the full-time student but several companies have made special arrangements to send their employees to selected classes in the program. Under these circumstances, a degree or diploma is not awarded.

The following precision tools need to be mastered during the course of the program:

- Fixed guages
- Micrometers
- Venier calipers
- Height guages
- Dial indicators
- Templates

The students will also acquire skills with the sophisticated coordinate axis machine, equipped with digital readout, optic comperators, and electronic amplifiers with accuracies to a millionth of an inch.

During the course of instruction, students have an opportunity to work on projects that are brought to them for inspection. In the lab, there is some equipment unique to that area to test for flaws and defects. For example, the City of Green Bay brought parts from the city run amusement park to be tested. A ski lift outift brought their components into the lab. Many local companies have also asked the students to routinely calibrate gages for them.

Courses offered and their descriptions follow.

PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION

First Semester

Course No	Description	Voc Credits
470-302	Industrial Processes	2
470-311	Precision Inspection	10
421-352	Blueprint Reading/and Sketching	2
442-355	Welding Inspection	2
804-354	Industrial Math I	2
		Total 18

Second Semester

Course No.	Description	Voc Credits
470-301	Inspection Metallurgy	2
470-312	Nondestructive Evaluation	10
623-140	Statistics	2
801-310	Inspection Communications	2
804-364	Industrial Math II	2
		Total 17

Graduation Requirements 35 Vocational Credits

COURSE DESCRIPTIONS

421-352 Blueprint Reading and Sketching 1 (Machine Trades) 2 Credits

Fundamentals of sketching, orthographic projection, dimensioning, working drawings sectional views, auxilliary views, production prints, mechanical drawings.

442-355 Welding Inspection 2 Credits

Welding Process, Weld Faults and Failures, Causes of Weld Faults; Solutions to Weld Faults; Visual Inspection of Welds; Inspection of Welds; Interpretation of AWS-ASME Codes of Welding, Weld Symbol Interpretation.

470-301 Inspection Metallurgy 2 Credits

Hardness testing, tensile testing, compression testing, tensile strength and ductility, weld strength, classification of metals, identification of metals, surface heat treatment, hardening, tempering, annealing of steels, and spectroscopic analysis of metals.

470-302 Industrial Processes 2 Credits

Material Casting, forging, rolling, joining, (welding, brazing, riveting), powder metal forming, machining, and heat treating, with their associated defects and dimensional change.

COMPETENCY BASED CURRICULUM

FOR

PRECISION INSPECTION

470-311

BY
EUGENE G. STACK

WE WISH TO ACKNOWLEDGE THE EXTENSIVE CONTRIBUTION OF BILL CRAIG TOWARDS THE DEVELOPMENT OF THIS PROGRAM

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
2740 West Mason Street
Green Bay, WI 54303
June, 1982

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Request for Course Approval

CURRICULUM ORGANIZATION FORMAT

X Outline

Prepared by: Date:

Eugene Stack 10/81

Review/Revisions by:

___ Instructional Plan/CBE

Prepared by: Date:

Review/Revisions by:

COURSE NUMBER 470-311

COURSE TITLE Precision Inspection

D.P. TITLE

DIVISION Industrial Trades

PROGRAM ASSIGNMENT Precision & Materials Insp.

SEM IN PROGRAM First

PREREQUISITES None

CREDIT BY EXAM ON FILE No

(Check One)

X Post Secondary ___ Adult-Vocational ___ Community Service

Total Potential Hours of Instruction	360
Classroom Hours/Week	5
Lab Hours/Week	15
Shop Hours/Week	
Clinical or Occupational Hours/Week	
Field Experience Hours. Week	
Total Student Hours/Week	20
Length of Course (Weeks)	18

AID CODE 31

MATERIAL CODE 05

CREDIT VALUE 10

STATE APPROVAL DATE 10/07/80

Course Description:

THIS COURSE PROVIDES THE OPPORTUNITY FOR THE STUDENT TO DEVELOP THE KNOWLEDGE, SKILLS, PROCESS AND UNDERSTANDING OF:

420-311 PRECISION INSPECTION 10 Credits

Micrometers, Venier Calipers, Height Gages, Dial Indicators, Electronic Coordinate Measuring Machines and Optic Comparators in addition to part set up.

Course Outline
Course Number: 470-311
Course Title: Precision and Inspection

COURSE OBJECTIVES

1. Justify the need for measurements.
2. Employ the language of measurement.
3. Utilize reference surfaces.
4. Measure with graduated scales and scaled instruments.
5. Measure with vernier instruments.
6. Measure with micrometer instruments.
7. Measure threads and gears.
8. Employ use of toolmakers microscope.
9. Evaluate dimensional set-up and inspection reports.
10. Discuss the evolution of standards
11. Measure with gage blocks.
12. Measure with dial indicators.
13. Apply calibration of instruments.
14. Measure with high amplification comparators.
15. Demonstrate the use of electronic high amplification instruments.
16. Measure with pneumatic instruments.
17. Measure with bore gages.
18. Design and measure with special gages.
19. Manipulate geometric tolerance in measurement.
20. Apply trigonometry to measurement.

Course Outline
Course Number 470-311
Course Title: Precision Inspection

STUDENT TEXT:

Title: Fundamentals of Dimensional Metrology
Author: Ted Rusch Publisher: Delmar
Date Adopted: 9/79 Copyright Date: 1964 Edition: 3rd

REQUIRED TEXTS:

Fundamentals of Dimensional Metrology, by Ted Busch, Delmar Publishers; Third Edition.

Laboratory Experiments-Fundamentals of Dimensional Metrology, by Ted Busch, Delmar Publishers

REFERENCES:

Related Assortment of Industrial Parts and Prints
Machinery's Handbook
Inspection and Gaging - Kennedy and Andrews, Industrial Press, 5th Edition
Handbook of Industrial Metrology, Society of Manufacturing Engineers, 1967
Quality Control Handbook, Juran, Third Edition
Measuring Systems and Standards Organizations, by W. K. Burton
Handbook of Dimensional Measurement by F. T. Farago
Notes - Instruments by E. G. Stack

VISUAL AIDS:

159 Dial Indicators
233 AE 121 Coordinate Measuring Machine
166 Vernier Calipers and Height Gages
162 Micrometer
287 Precision Tools
Tallyround - Roundness

MTI

026 Labor Saving
018 Dial Indicators

E. G. Stack - Slides on Dimension Set-Up

PRECISION INSPECTION

SO YOU WILL KNOW

YOUR GOAL IS OUR GOAL:

Thank you for selecting Precision Inspection as your field of study. As your instructor, I am committed to serve and train you to fulfill your career goals.

Your mind and skills are the greatest assets you have. How well you develop and employ them determines your success in life.

In order to accomplish our objective, we have stated for your information the mode of operation in class.

GRADING SYSTEM	FINAL GRADE
Laboratory Projects	1/2
Tests & Quizzes (Quiz = 1/2 Test)	1/4
Final Examination	1/4

You are requested to be on time for class. Coming in late disturbs the class. Being absent -- you can't do the work if you are not here.

Laboratory assignments for the week will be posted on the board.

Laboratory assignments for the week will be posted on the board.

Laboratory projects for the week are to be turned in complete by the first day of class of the following week. Late projects will loose 5%. Inspection reports are needed on time to keep machines running in the shop. You may work in groups but each individual is to do his or her own work in its entirety. Complete all projects and prints.

You are permitted to make up one test during the course. If more than one test is missed, your grade will be so reflected.

Please sign attendance sheet for each class.

Reliably yours.

Gene Stack
1/29/82

Course Outline
Course Number: 470-311
Course Title: Precision Inspection

Course Objectives:

I. What is Quality

   A. Evolution of Quality Organization
   B. Quality Cycle
   C. Quality of Design - of Manufacture
   D. Reasons for Measurement

II. Language of Measurement

   A. Basic Terms
   B. Systems of Measurement

III. Reference Surfaces

IV. Measurement with Graduated Scales and Scaled Instruments

   A. Evaluation of Rules and Scales
   B. Handling of Steel Rules and Scales
   C. Scale Selection
   D. The Importance of Parallax
   E. Role of the Depth Gage
   F. Role of the Combination Square
   G. Dividers and the Accumulation
   H. The Caliper for Transfer Measurement
   I. Considerations for Caliper Transfers
   J. Transfer Measurements with Surface Gage to Height Master
   K. Lay-Out

V. Measurement with Vernier Instruments

   A. The Vernier Instruments - Dial vs Slide
   B. The Role of the Vernier Caliper
   C. Cylindrical Measurement with the Vernier Caliper
   D. The Tole of the Vernier Height Gage - Dial vs Slide
   E. The Relationship of Feel and Height
   F. Use of Test Indicator with Height Gage

VI. Measurement with Micrometer Instruments

   A. The Micrometer Instruments
   B. Reading the Micrometer
   C. Precision with the Micrometer
   D. Micrometer Accuracy

Course Outline
Course Number : 470-311
Course Title: Precision Inspection

VI. Measurement with Micrometer Instruments (cont.)

E. Cylindrical Measurement with the Micrometer
F. Finish and Material Affect Micrometer Feel
G. Accuracy of Cylindrical Measurement
H. Hidden Errors with Micrometer Measurement
I. The Inside Micrometer
J. The Depth Micrometer
K. Small-Hole Gages
L. Telescope Gages

VII. Threads - Gears

A. Nomenclature
B. Size and Specs
C. How to Measure

VIII. Toolmakers Microscope

IX. Dimensional Inspection Report

A. Function
B. How to Use - Purpose
C. Part Set-Up

X. Evolution of Standards

A. The Role of Standards
B. Measuring in Millionths
C. The Development of Gage Blocks
D. Line Standards and End Standards
E. Characteristics of Gage Blocks
F. Gage Block Specifications
G. Gage Block Calibrations

XI. Measurement with Gage Blocks

A. Gage Block Care
B. Individual Gage Block Use
C. Wringing Gage Blocks
D. Combining Gage Blocks
E. Checking a Micrometer
F. The Wringing Interval
G. Finding the Dimension
H. Forming Small Dimensions
I. Use of Gage Block Holders

Course Outline
Course Number: 470-311
Course Title: Precision Inspection

XII. Measurement with Dial Indicators

- A. The Dial Indicator
- B. The Importance of a Reference Surface
- C. Types of Measurement
- D. Indicator Selection
- E. The Importance of Feel
- F. The Inherent Accuracy of Dial Indicators
- G. Continuous and Balanced Dials
- H. Dial Comparator Setups
- I. Positional Relationships
- J. Using the Flat Point - Various Tips
- K. Role of the Wide-Face Point

XIII. Calibration

- A. Optical Flats
- B. Calibration Schedule
- C. Records - Traceability

XIV. Measurement with High Amplification Comparators

- A. Introduction to the Electronic Comparators
- B. Zero Setting
- C. Electronic Height-Gage Inspection
- D. Electronic Height-Gage Measurement
- E. Amplification and Surface Finish
- F. The Inherent Accuracy of the Electronic Comparator
- G. Roll of the Three-Point Anvil
- H. The Ten-To-One Rule
- I. Electronic Gaging and Cosine Error
- J. Continuous Loop of Electronic Equipment

XV. Use of Electronic H/A Equipment

- A. Coordinate Measuring Machine
- B. Optical Comparator
- C. Super Mic
- D. Profilemeter
- E. Federal
- F. Doall
- G. Tallyround

XVI. Pneumatic Instruments and Bore Gages in Measurements

XVII. Design of and Measurement with Special Gages

XVIX. Review

COURSE NO. 470-311

PRECISION INSPECTION

INSTRUCTOR Gene Stack

MODULE/UNIT NO. I

INSTRUCTIONAL PLAN

DATE 06-03-82

TERMINAL COMPETENCY: Justify the need for measurements.

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Define quality	Activity	Verbal Quiz
2. Differentiate between quality of design and manufacturing	Lecture and group discussion Questionnaire on knowledge of prints and gage use	Unit Test
3. Discuss evolution of quality in U.S.	Resource Text Chapter I Measuring Systems and Standard Organizations W. K. Burton	
4. Discuss the concept of Quality Cycle or quality spiral	Quality Planning and Analysis Juran -- Gryna 1st ed. McGraw - Hill Chpt 1 & 2	
5. Conclude from the sequence above the need for measurements		

COURSE NO. 470-311

PRECISION INSPECTION

INSTRUCTOR Gene Stack

MODULE/UNIT NO. II

INSTRUCTIONAL PLAN

DATE 06-03-82

TERMINAL COMPETENCY: Employ the language of measurement

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Explain dimensional measurements	Activity Lecture and group discussion practive problems	Written Quiz Unit test
2. Define feature or characteristics	Resources Text Chpt 2 & 3	
3. Differentiate between: Accuracy Precision Reliability	Measuring Systems and Standard Organization W. K. Burton	
4. Convert English to Metric measuring systems	Q. C. Handbook 3rd ed. by Juran sect 13-2 to 13-12	
5. Explain why metric is here to stay in the U. S. of A.		
6. Demonstate the rules in rounding off numbers		

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. III INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Utilize reference surfaces

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Describe basic need for reference point, bench mark, "Datum"	Activity Lecture - Demonstration Discussion - Review Lab Experiment	Evaluate lab experiment
2. Illustrate surface plates and angle plates as basic lab reference surfaces - discuss accuracy	Resource Text Chapter 15	
3. Develop 3 plate method for generating flat surfaces	Lab Experiment 15.1 15.2 15.3	
4. Explore advantages of granite surface plant over cast iron	Handbook of Dimensional Measurement by Farago, pages 259-282	
5. Appraise the use of precision levels		
6. Combine the use of a surface plate in lab projects		

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. IV INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Measurement with graduated scales and scaled instruments

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Explain the use of rules and scales	Activity Lecture - Demonstration	Evaluate lab experiment
2. Assess scales selection	Descussion - lab experiment	Unit test
3. Describe importance of parallay	Resource Text Chapter 4 & 5	
4. Illustrate use of combination square inside - outside calipers dividers- in transfer measurements	Lab experiment 4.1 5.1 lay out samples 4.2 5.2 4.3 5.3 4.4 5.4 5.5	
5. Apply use of the above in lay out work	Hand out notes: use of Height Master by E. G. Stack	
6. Apply transfer measurements with surface gage to height master	Hankbook of Dimensions Measurement by Farago, pages 9-16	

COURSE NO. 470-311	PRECISION INSPECTION	INSTRUCTOR Gene Stack
MODULE/UNIT NO. V	INSTRUCTIONAL PLAN	DATE 06-03-82

TERMINAL COMPETENCY: Measurement with Verneir instruments

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Explain concept of amplification	Activity	Evaluate lab experiment
2. Describe nomenclature reading - use, care and precautions for vernier caliper	Demonstration - Discussion Lab experiment Pre test on ability to read blue prints	Unit Test
3. Appraise use of dial vs slide verneir	Resource Text chpt 6	
4. Exploy technique for measuring cylinders and squares with vernier	Lab exp 6.1 6.4 6.2 6.5 6.3 Introduce parts and prints as lab project	
5. Contrast use of height gage with and without test indicator - use with reference standards	Handbook of Dimensions Measurements by Farago, pages 16-20 Video tape 166 caliper Height gages	
6. Familarize dimensioning production parts from prints	Filmstrip - Vernier instrument Wall poster - use of Vernier	

COURSE NO. 470-311

MODULE/UNIT NO. VI

PRECISION INSPECTION

INSTRUCTIONAL PLAN

INSTRUCTOR Gene Stack

DATE 06-03-82

TERMINAL COMPETENCY: Measurement with micrometer instruments

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Explain nomenclature reading - use - care and precautions for micrometer	Activity Lecture - demonstration Practice problems Lab experiments - parts & prints Review Units I-VI for test	Evaluate lab experiment
2. Practice reading Mic to 3 and 4 decimal places - precision	Resource Text Chpt 7 Handbook of Dimensional Measurment by Farago, pages 20-26	Units I-VI test given
3. Employ techniques for measuring cylinders and flat surfaces with mic-effect of finish rock over method	Lab exp 7.1 7.8 7.2 7.9 parts and prints 7.3 7.10 7.4 7.11	Note: Use of part to print dimensioning in future classes will incorporate the use of all previously learned techniques and instument application
4. Describe use and function of mic with other tools telescope gages small hole gages calipers	7.5 7.12 7.6 7.7 Mitutoyo "Micrometer Guide Book"	Accurate part to print dimensioning is the culminate objective of this course
5. Extrapolate use of other mic tools, depth. mic - inside mic special Mics - Mic Heads	Video tape #612 micrometers Film strips - Micrometers and Gage Blocks Wall poster how to use Mic	

COURSE NO. 470-311

PRECISION INSPECTION

INSTRUCTOR Gene Stack

MODULE/UNIT NO. VII

INSTRUCTIONAL PLAN

DATE 06-03-82

TERMINAL COMPETENCY: Measurement of threads and gears

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Associate thread nomenclature and identification system	Activity Lecture - demonstration class projects with threads Lab experiment Parts and prints	Evaluate lab experiment Unit test
2. Apply thread identification system to finding technical data in Machinery's Handbook	Resources Machinery's Handbook 21st ed., Threads, pages 1256-1408 Measuring, pages 1383-1408 and 955, 964 Gears, pages 711-966	
3. Utilize measuring techniques to check threads employing a) thread mic b) wires c) optical comparator d) thread gages e) toolmakers microscope	Hand out notes on threads and gear nomenclature for measurement Overhead projector - Appendix A Three wire method of measuring pitch diameter	
4. Assess Van Keuren measuring system for gears	Prints and Parts Lab exp 19.2	

COURSE NO. 470-311

PRECISION INSPECTION

INSTRUCTOR Gene Stack

MODULE/UNIT NO. VIII

INSTRUCTIONAL PLAN

DATE 06-03-82

TERMINAL COMPETENCY: Use of toolmakers microscope

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Acquire eye to hand skill in use of toolmaker mic (TMM)	Activity Lecture-demonstration Class project with toolmaker mic	Evaluate lab experiment
2. Appraise features measurable with TMM; the first multi-function measuring tool a) Length - width b) Diameter c) Angle d) Surface finish e) Threads	Lab experiment Resource Hand out notes on use of toolmakers microscope by E. G. Stack Lab experiment TMM Prints and Parts Handbook of Dimensional Measurement by Farago, Chpt 8, Engineering Microscope	Unit test

COURSE NO. 470-311

MODULE/UNIT NO. IX

PRECISION INSPECTION
INSTRUCTIONAL PLAN

INSTRUCTOR Gene Stack

DATE 06-03-82

TERMINAL COMPETENCY: Evaluate dimensional set-up and inspection reports

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Assess the need to report measurements on an organized report in a meaningful and understandable manner. Accurately generate part dimensions to print requirements	Activity Demonstration on how to mark print and fill out inspection report so engineering can understand Demonstrate set-up	All future projects will be on inspection reports and so evaluated
2. Produce accurate reports which state what's inspected. With no engineering comments, our job is to check; Engineering to Judge	Resource Slides on dimensional set-up by E. G. Stack Blue print reading course	Unit test
3. Apply basic principles of part set up before taking dimensions.		

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. X INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Evolution of Standards

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Describe the role of standards 2. Demonstrate Measuring in Millionths 3. Describe the development of gage blocks 4. Differentiate between line standards and end standards 5. Explain functional characteristics wanted in gage blocks 6. Explain specifications for gage blocks that are required by the Federal Government. 7. Explain important considerations relative to gage block calibration.	Lecture/Demonstration Classroom Discussion Print & Part Test: Chapter 8 Additional Resources: Handbook of Industrial Metrology by The Society of Manufacturing Engineers LRC T 50 A A4 Chapter 4 Prints & Parts	Evaluate lab experiment Unit test

COURSE NO. 470-311

MODULE/UNIT NO. XI

PRECISION INSPECTION

INSTRUCTIONAL PLAN

INSTRUCTOR Gene Stack

DATE 06-03-82

TERMINAL COMPETENCY: Measurement with Gage Blocks

SPECIFIC OBJECTIVES

- Demonstrate care of gage blocks
- Demonstrate individual gage block use - wear blocks
- Demonstrate wringing gage blocks
- Demonstrate technique for combining specific stacks of gage blocks
- Demonstrate checking a micrometer
- Explain the writing interval
- Demonstrate the Bridging technique - Universal Principle of QA
- Demonstrate how dimensions smaller than .100 in. can be formed with standard gage block sets
- Evaluate gage block holders and multi uses as:
  - a) Standards-comparator
  - b) Go-no go gage
  - c) In lab-in production

LEARNING ACTIVITIES AND RESOURCES

Lecture/Demonstration
Classroom discussion
Laboratory Experiments
Review Units VII-XI
Text: Chapter 9

Lab exp	Text page no.
9.1	156-161
9.2	142-143
	156-157
9.3	156-163
9.4	163-165
	293-294
9.5	163-165
	293-294
9.6	158-159
9.7	165-166
9.8	164-165
9.9	Prints & Parts
9.10	
9.11	
9.12	

Machinery's Handbook
21st ed
Industrial Press, pages 1897-1899
Handbook of Dimensional Measurement
by Farago Chpt 4, Gage Blocks

EVALUATION METHOD

Evaluate lab experiment
Unit VII-XI test given

COURSE NO. 470-311
MODULE/UNIT NO. XII

PRECISION INSPECTION
INSTRUCTIONAL PLAN

INSTRUCTOR Gene Stack
DATE 06-03-82

TERMINAL COMPETENCY: Measurement With Dial Indicators

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES		EVALUATION METHOD
1. Describe the nomenclature of the dial indicator 2. Demonstrate the importance of the reference surface when using comparison instruments 3. Demonstrate the two basic types of measurement, direct (displacement) and comparative (Interchange) and show their basic differences 4. Explain the relationship between amplification and precision, and to show the importance of amplification in indicator selection. 5. Demonstrate that the shape of parts affects the feel of the measurement and thereby influences the results. 6. Demonstrate that dial indicators contain easily measurable errors.	Lecture/Demonstration Classroom discussion Laboratory Experiments	Text: Chapter 10 Lab exp. No. — Text page No. 10.1 — 188-197 10.2 — 209-216 10.3 — 82- 84 10.4 — 184-200 10.5 — 72, 86, 87, 112, 117, 118 10.6 — 197, 199 10.7 — 195, 205 10.A Prints & Parts Video Tape 159 Dial Indicator MTI film 018 Dial Indicator Handbook of Dimensional Measurement, by Farago Cpt 5, pages 64-85	Evaluate lab experiment Unit test
7. Demonstrate the application of continuous and balanced dials for unilateral and bilateral tolerances 8. Demonstrate that geometry, finish, size and tolerance all affect the comparator setup 9. Demonstrate the positional problems that result from the use of indicators accessories 10. Demonstrate one role for flatpoints and show the technique for using them and other shaped points	Laboratory experiments	Text: Chapter 10 Lab exp. — Text page 10.8 — 207-214 10.9 — 214-218 10.10 — 211-218 10.11 — 211-218 Prints & Parts	

COURSE NO. 470-311	PRECISION INSPECTION	INSTRUCTOR Gene Stack
MODULE/UNIT NO. XIII	INSTRUCTIONAL PLAN	DATE 06-03-82

TERMINAL COMPETENCY: Apply calibration of instruments

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Define calibration and apply calibration techniques to QC instruments 2. Employ traceability of standards through the scalar principles 3. Differentiate among the three types of measuring errors 4. Manipulate the four types of calibration checks 5. Utilize calibration schedules (procedures) to calibrate instruments 6. Identify use of optical flats as a topography tool in calibration 7. Interpret deformation measurements using optical flats 8. Complete and maintain calibration records, properly label instruments	Activity Lecture/Demonstration Calibrate - Mic Height Gage Vernier Dial Indicator Depth Mic Special Instruments Audit - other students calibration Lab experiment Resources QC Handbook 3rd ed. by Juran Sect 13-13 to 13-18 Text Chpt 13; chpt 14 Calibration schedules, A, B, C, D, E Hand out optical flats by E. G. Stack Lab experiment 13.1 14.1 14.2	Evaluate calibration project Unit test

COURSE NO. 470-311

PRECISION INSPECTION

INSTRUCTOR Gene Stack

MODULE/UNIT NO. XIV

INSTRUCTIONAL PLAN

DATE 06-03-82

TERMINAL COMPETENCY: Measurement With High Amplification Comparators

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES			EVALUATION METHOD
1. Explain the Electronic comparator, its nomenclature and use. 2. Demonstrate General setup and handling of an electronic comparator and role of the probe head in electronics measurement 3. Explain the difference between inspection and measurement, using the probe head on the part inspected in Exp. 11.3 4. Demonstrate that high amplification requires fine surface textures 5. Discover advantages of multiple scale 6. Explain the practical results of the ten-to-one rule in a typical situation - Key to Good Control 7. Demonstrate the problem of cosine error when using probe heads. 8. Compare four means of high amplification 9. Explain advantages of electrical amplification over other types 10. Recognize the influence of temperation on accurate measurement.	Lecture/Demonstration Classroom Discussion Laboratory Experiments Prints & Parts Review Units XII-XIV	Text: Lab exp. no. 11.1 11.2 11.3 11.4 11.5 11.6 11.7 11.8 11.9 11.11 Prints & Parts See Unit XV for additional resource information	Chapter 11 Text page no. 247-258 231-250 243-246 243-246 242-250 243-252 249-250 298-299 237, 242 243, 246	Evaluation of lab experiment Unit XII-XIV test given

COURSE NO. 470-311

MODULE/UNIT NO. XV

PRECISION INSPECTION

INSTRUCTIONAL PLAN

INSTRUCTOR Gene Stack

DATE 06-03-82

TERMINAL COMPETENCY: Use of Electronic High Amplification Instruments

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Develop continuous loop in use of electronic measuring equipment 2. Apply skillful use and manipulation of major high amplification equipment a) Coordinate measuring machine b) Optical comparator c) Supermic d) Profilometer e) Tally round f) Doall comparator g) Federal gage	Activity Demonstration/Lecture Student training one on one Prints & Parts Instruments will be introduced one at a time over a period of time to gain proficiency in their use Resources Text Chpt ii Some technical paper talking roundness Handbook of Dimensional Measurements by Farago, Chpt 7 Electronic Gages Hand outs 1. Continuous loop of electronic equipment 2. Supermic 3. Reading optical comparator - gage block use 4. Tally round operation 5. Finding hole centers Video tape #233 AE 121 Coordinate Measuring Machine Video tape #287 Precision Tools Tally Round Roundness MTI film #026 Labor Saving Prints and Parts	Evaluation of lab experiment Unit test One on one evaluation of skill and comprehension of instrument

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. XVI-A INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Measurement With Pneumatic Instruments

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES			EVALUATION METHOD
1. Explain pneumatic metrology, its nomenclature and use. 2. Demonstrate the use of pneumatic instruments for bore gage setups and show their freedom from hysteresis - other in process controls 3. Distinguish between various types of air gage systems 4. Classify advantage of flow meter over other measuring systems 5. Recognize the use of electronic read out coupled with pneumatic instruments two systems in one	Lecture/Demonstration Classroom Discussion Laboratory Experiments Parts & Prints	Text: Lab exp. no. 12.1 12.2 Parts & Prints Hand out Gaging with Air by Edmunds Mfg. Co. Handbook of Dimensional Measurement, by Francis T. Farago, PhD, Industrial Press, Chpt 6	Chapter 12 Text page no. 259-277 267, 269	Evaluation of lab experiment Unit test

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. XVI-B INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Measurement With Bore Gages

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Identify the various types of bore gages 2. Explain the advantages and disadvantages of the various methods of checking bores and holes 3. Recognize which type of instrument to use depending upon discrimination and tolerance requirements 4. Apply the use of bore gages using a) Setting rings b) Gage blocks c) Setting masters	Activity Lecture/Demonstration Class practice Lab experiment 17.1 17.2 Prints & Parts Resource Handbook of Dimensional Measurement by Farago, pages 85-95 Hand outs: Reading Dial Bore Gages Reading Mic Head Bore Gages	Evaluation of lab experiment Unit test

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. XVII INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Design and Measurement With Special Gages

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Differentiate between gage and instrument 2. Employ the use of various standard gages a) Ring gage b) Plug gage c) Snap gage d) Thread gage 3. Design special go-no go gage for a special application employing the principles of gage tolerancing following 10.1 rule	Activity Lecture/Demonstration Class Practice - Design gage and submit working sketch of design, prints and parts Resources Text page 209 Machinery's Handbook, 21st ed, Industrial press "Gages" pages 1900-1920 *Handbook of Dimensional Measurement* by Farago, "Fixed Gages" chpt 3 Hand out: Go-no gages EGS Astme "Tool Engineers Handbook" 2nd ed, F. W. Wilson, page 457, Methods of Allocating Gage Tolerance Prints & Parts	Evaluation of Gage Design Unit test

COURSE NO. 470-311 PRECISION INSPECTION INSTRUCTOR Gene Stack

MODULE/UNIT NO. XVIII-B INSTRUCTIONAL PLAN DATE 06-03-82

TERMINAL COMPETENCY: Applying Trigonometry in Measurement

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Compute trignometric solution for print tolerances given a) Angle find coordinates b) Coordinates find angle 2. Employ Sin/Cos x radius method for hole location 3. Apply methods of measuring angles a) Protractor b) CMM c) Toolmakers microscope d) Optical comparator e) Sine bar 4. Produce angles with Sin bar using gage blocks - parallels 5. Generate measurement of tapers employing various methods	Activity Pretest for competency in trigonometry Lecture/Demonstration Problem Solving Prints & Parts Lab exp 18.1, 18.2 Review units XV - XVIII Resources Mathematics for Technical and Vocational Schools 1st ed, Unit 13 Trigonometry Unit 16 Tapers Handbook of Dimensional Measurement by Farago, Chpt 10 Angle Measurements Machinery's Handbook, 21st ed, Trigonometry pages 170-222, Sin Bar - Taper, pages 1585-1599	Evaluation of lab projects Class Problem Review Unit XV-XVIII test given

COURSE NO. 470-311
MODULE/UNIT NO. XVIII-A

PRECISION INSPECTION
INSTRUCTIONAL PLAN

INSTRUCTOR Gene Stack
DATE 06-03-82

TERMINAL COMPETENCY: Geometric Tolerance in Measurements

SPECIFIC OBJECTIVES	LEARNING ACTIVITIES AND RESOURCES	EVALUATION METHOD
1. Differentiate various tolerances a) Symmetrical b) Bilateral c) Unilateral 2. Compute fit of mating parts a) Allowance b) Clearance c) Interence 3. Assess concepts of datum - MMC - true position RFS 4. Apply geometric characteristic symbols and tolerance to practical problems including print interpretation	Activity Lecture/Demonstration Problem solving Prints & Parts Resources Interpreting engineering drawings by Jensen & Hines, Delmar Publishers Unit 40 Geometric Dimensional and Tolerancing Basic Fundamentals, by David A. Madsen the Goodheart - Wilcon Co. Class hand out: Geometric Tolerance and True Position, source unknown, Prints & Parts	Evaluations of lab experiments problem solving review Unit test

NORTHEAST WISCONSIN TECHNICAL INSTITUTE
Request for Course Approval

CURRICULUM ORGANIZATION FORMAT

____Outline

Prepared by: Date:

William Craig

Review/Revisions by

Don Faull 5/82

____Instruction Plan/CBE

Prepared by: Date:

Review/Revisions by: Date:

COURSE NUMBER 470-312

COURSE TITLE Non-Destructive Examination

D. P. TITLE ____

DIVISION ____

PROGRAM ASSIGNMENT ____

SEM IN PROGRAM ____

PREREQUISITES ____

CREDIT BY EXAM ON FILE? ____

(Check One)

____Post Secondary ____Adult Vocational ____Community Service

Total Potential Hours of Instruction 360
Classroom Hours/Week 5
Lab Hours/Week 15
Shop Hours/Week ____
Clinical or Occupational Hours/Week ____
Field Experience Hours/Week ____
Total Student Hours/Week 20
Length of Course (Weeks) 18

AID CODE 31
MATERIAL CODE 04
CREDIT VALUE 10.00
STATE APPROVAL DATE ____

Course Description:

THIS COURSE PROVIDES THE OPPORTUNITY FOR THE STUDENT TO DEVELOP THE KNOWLEDGE, SKILLS, PROCESS AND UNDERSTANDING OF:

Educational experience and skill development to utilize non-destructive testing methods to locate hidden flaws, cracks, and unseen material conditions which would cause a part to fail. These methods include penetrant testing, magnetic particle testing, eddy current testing, ultrasonic testing and radiographic testing.

Course Outline
Course Number: 470-312
Course Title: Nondestructive Examination

STUDENT TEXT:

Title: Nondestructive Testing
Author: General Dynamics Publisher:
Date Adopted: 9/79 Copyright Date: 1967 Edition: 1st

Nondestructive Testing: Liquid Penetrant Testing
Nondestructive Testing: Magnetic Particle Testing
Nondestructive Testing: Eddy Current Testing
Nondestructive Testing: Ultrasonic Testing
Nondestructive Testing: Radiographic Testing

REFERENCES:

Special Process: Penetrant Inspections
Radiographic Inspection
Magnetic Particle Inspection

Principles of Penetrants
Nondestructive Inspection and Quality Control

VISUAL AIDS

249 Quality of Radiographs
250 Panel - Radiography - Questions and Answers
246 Radiographic Processes
245 Radiography and Costs
166 Standards Specifications and Codes
77 Ultrasonics
159 How to use the Uresco

Course Outline
Course Number: 470-312
Course Title: Nondestructive Examination

Course Objectives:

Penetrant Testing

1. Equipment
2. Surface Preparation
3. Penetrants
4. Washing
5. Developer
6. Inspection with Blacklight
7. Evaluation Techniques

Magnetic Particle Testing

1. Equipment
2. Principles
3. Flux Fields
4. Surface Discontinuities
5. Surface Defects
6. Circular Defects
7. Longitudinal Techniques
8. Evaluation Techniques

Eddy Current Testing

1. Equipment
2. Test Coil Arrangements
3. Impedence Plane Response
4. Eddy Current Principles
5. Impedence
6. Permeability
7. Field Strength
8. Test Indications
9. Test Object and Circuitry
10. Irregularity Recognition
11. Evaluation

Ultrasonic Testing

1. Equipment Categories
2. Equipment Functions
3. Test Systems
4. Wave Propagation
5. Testing Techniques
6. Calibration
7. Defect Detections
8. Evaluation

Radiographic Testing

1. Equipment
2. Radiation
3. Procedures
4. Evaluation Techniques

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TERMINAL OBJECTIVE: I. Identify Defects in Manufactured Parts

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LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
I-A. Explain the wrot product manufacturing process.	The making, shaping, and treating of steel by U.S. Steel Corp. (Text) Iron and Steel Institute a) Iron & Steel Cook Book b) The Steel Making Industry		Unit I Examination "Penetrant" Weekly Quiz I Classroom Discussion
I-B. Classify discontinuities in: a) Castings b) Forgings c) Welding d) Heat treating e) Machining	Videc Tapes a) Cast a Giant Shadow AFS b) Casting G.E. turbine div. c) Forging, a Pivotal System F.I.A. Handout Innerent and Process discontinuities Magnaflux Corporation	Examination of sample parts	1) Laboratory notebook 2) Weekly Quiz I 3) Unit I exam "Penetrant"

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TERMINAL OBJECTIVE: II. Use of specifications as an aid to establish test procedures.

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
II-A. Explain specification format components.	1) ASME Boiler Code article 6 & 7 2) MIL-I-6868 3) MIL-STD-410		Laboratory notebook
II-B. Relate specifications to test procedures	Examine sample test procedure	1) Write a test procedure 2) Have another class member perform test according to procedure.	Laboratory notebook

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TERMINAL OBJECTIVE: III. Perform, interpret and evaluate a penetrant test.

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
III-A. Identify types of penetrants	Nondestructive testing volume CT-6-2 "Liquid Penetrant" pages 3-3 thru 3-15	Demonstration of types of penetrant tests.	Weekly Quiz II Unit I test
III-B. Perform penetrant examination procedure	CT-6-2 pages 4-3 thru 4-20 1) Video tape "Penetrant Testing" by MPL Labs 2) Penetrant procedure handout by Magnaflux Corp. 3) "Penetrant Testing" filmstrip by Convair Div. of General Dynamics	Perform penetrant test on sample parts.	Laboratory notebook Weekly Quiz II Unit I test

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TERMINAL OBJECTIVE: IV. Perform, interpret and evaluate a penetrant test.

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
IV-A. Explain penetrant indications	CT-6-2 pages 5-1 thru 5-19	Interpretation of indications on sample parts.	Laboratory notebook
IV-B. Quality control of penetrant systems.	CT-6-2 pages 6-1 thru 6-11	Write quality control test procedure for laboratory penetrant tanks.	Laboratory notebook
		Perform quality control tests on penetrant tanks.	Unit I test Weekly Quiz II

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TERMINAL OBJECTIVE: V. Perform, interpret, and evaluate a magnetic particle test (Basic principles)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
V-A. Identify types of magnetic particle test.	Nondestructive testing volume CT-6-3 "Magnetic Particle", pages 3-3 to 3-11.	Demonstration of types of magnetic particle inspection	Weekly Quiz I Unit III test
V-B. Relate scientific principles of electricity and magnetism to magnetic particle inspection.	CT-6-3 Chapter 2	Calculate, predict and evaluate a magnetic field on different test parts.	Unit II test Laboratory notebook Weekly Quiz III
a) Explain the theory of domains and magnetism	CT-6-3 pages 2-5 & 6		

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TERMINAL OBJECTIVE: V. Perform interpret and evaluate a magnetic particle test. (continued)
(Material Properties and magnetic fields)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(V-B continued)			
b) Explain how magnetic fields and polarity relates to flux density and vector fields.	CT-6-3 pages 2-6 to 2-10		Unit II Exam Weekly Quiz VI
c) Relate electricity to induced magnetic fields. 1) Flux density 2) Hysteresis loops 3) Longitudinal magnetization 4) Circular magnetization	CT-6-3		Unit II exam Weekly Quiz VI
d) Diagram field distribution on magnetic or non-magnetic conductors and effect of field geometry	CT-6-3 pages 2-16		Unit II exam Weekly Quiz V
e) Predict types of current to ultimate magnetization 1) AC 2) DC 3) 1/2 wave rectified 4) full wave rectified	CT-6-3 pages 2-24 to 2-26		Unit II exam Weekly Quiz V

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TERMINAL OBJECTIVE: V. Perform, interpret and evaluate magnetic particle test. (continued) (Procedure)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(V-B continued)			
f) Calculate necessary amperages for magnetization	CT-6-3 pages 2-26	Testing on sample parts	Laboratory Notebook Weekly quiz IV
g) Explain requirements for demagnetization	CT-6-3 pages 2-31 to 2-34		Unit II test Weekly quiz IV
V-C. Perform magnetic particle examination	CT-6-3 pages 5-3 to 5-17 Video tape "Magnetic Particle Testing" by MPL Laboratories	Perform test on sample parts	Laboratory notebook

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TERMINAL OBJECTIVE: VI. Perform and interpret a magnetic particle examination.

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
VI-A. Explain magnetic particle test indications	CT-6-3 pages 6-3 thru 6-17	Interpretation of indications on sample parts	Laboratory notebook
VI-B. Evaluate the quality of magnetic particle systems.	CT-6-3 pages 4-3 thru 4-8	Write quality control list procedure for laboratory magnetic particle unit Perform quality control tests on the laboratory magnetic particle unit.	Laboratory notebook Unit II exam

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (Ultrasonic Energy)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
1. Explain energy motion and wave forms a) Sound waves (longitudinal) b) Electromagnetic waves (transverse)	CT-6-4 Nondestructive testing (Ultrasonic testing) pages 2-5 thru 2-6 ASNT filmstrip package Ultrasonics - introduction		Unit III test "Ultrasonic Testing" (T III) Weekly quiz VII
2. Explain piezo electricity ane relate it to generating and reception of ultrasonic energy	CT-6-4 pages 2-6 and 2-7		Weekly quiz VII T III
3. Explain the relation ship of: a) Frequency b) Wave length c) Velocity d) Period	Ultrasonic formulas and study guides by Magnaflux Corporation pages 1 and 2 ASNT filmstrip package Ultrasonics - part 1		T III Weekly quiz VII

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued)
(Ultrasonic display and basic equipment)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 4. Relate refraction, reflection, and absorption to an ultrasonic presentation.	CT-6-4 pages 2-7 and 2-8	Use ultrasonic units and observe reflections from known defects	T III Lab notebook Weekly quiz VII
5. Explain the relationship of time and distance and relate this to the oscilloscope presentation.	CT-6-4 pages 2-8 thru 2-10	Calibrate ultrasonic units to a step block	Lab notebook
6. Explain the oscilloscope presentation to the functions of the: a) Pulser b) Time generator c) Amplifier d) Transducer	CT-6-4 pages 2-10 thru 2-11 ASNT filmstrip package part 2		T III Weekly quiz VIII
7. Relate oscilloscope controls to display a) Sweep delay b) Sweep length c) Range markers d) Repetition rate e) Slope	CT-6-4 pages 2-11 to 2-13	Calibrate ultrasonic instument over a variety of different part thickness to detect differ- known defects	T III Lab notebook Weekly quiz VIII

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued)
(Ultrasonic wave physics)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 8. Calculate wave responses to changes in: a) Velocity b) Frequency c) Wavelength	An Ultrasonic Testing Course Unit I, The Metric System and Algebraic Formula pages 1 and 2 by Andy Struzyk	Calculate results of sample problems	T III Weekly quiz IX
9. Relate the nature of sound waves to atomic vibration in a material.	UTC by A. Struzyk pages 3-5 CT-6-4 pages 2-17 to 2-19		T III Weekly quiz IX
10. Explain the principles of through transmission ultrasonic testing a) Acoustic impedance b) Reflection factor c) Permeability factor	UTC by A. Struzyk pages 7-9	Perform a through transmission ultrasonic test on known defects Calculate reflection and permeability factors in several examples	T III Lab notebook Weekly quiz IX
11. Explain the principles of pulse echo testing a) Piezo and reverse piezo electricity b) Converting inches of any material to inches of a known material utilizing velocity proportions.	UTC by A. Struzyk pages 9-14	Perform a pulse echo ultrasonic test on known defects.	T III Lab notebook Weekly quiz IX

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued)
(Flaw size determination)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 12. Perform a multiple echo, pulse echo ultrasonic test for measuring thickness.	UTC by A. Struzyk page 12	Measure thickness utilizing the multiple echo technique.	T III Lab notebook Weekly quiz X
13. Explain the difference between electrical and acoustical "O" and relate them to the use of delay blocks and immersion testing.	UTC by A. Struzyk page 13	Ultrasonic test (pulse echo) parts with known defects utillizing delay blocks and immersion	T III Lab notebook Weekly quiz X
14. Determine flaw size from back reflection amplitude.	CT-6-4 pages 2-27, 2-28, 2-36 UTC by A. Struzyk pages 15-22	Ultrasonic test (pulse echo) parts with known defects and compensate for different depths	T III Lab notebook Weekly quiz X
a) Geometry of the sonic filed 1) dead zone 2) freshel zone 3) Fraunhoffer zone 4) secondary	CT-6-4 2-17 & 28	Calculate angle of divergence Calculate freshcl zone limit	T III Weekly quiz X
b) Application of the D.G.S. diagram	UTC by A. Struzyk pages 17-19		
c) D.G.S. procedure	UTC by A. Struzyk pages 20-22		

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TERMINAL OBJECTIVE: VII. Perform, interpret, and evaluate an ultrasonic test (continued) (Angle beam refraction)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 16. Explain reflection, refraction, and mode conversion.	CT-6-4 pages 2-19 to 2-21 UTC by A. Struzyk pages 28-30 ASNT filmstrip series part 3		T III Weekly quiz XI
17. Calculate refracted beam angles utilizing Snell's law.	CT-6-4 pages 2-22, 23 UTC by A. Struzyk pages 31, 32		Q III Weekly quiz XI
18. Calculate critical angles of refraction	CT-6-4 pages 2-23 to 2-25		Q III Weekly quiz XI
19. Explain the different types of couplants and and the uses of each.	CT-6-4 pages 2-31 to 2-32 ASNT filmstrip U.T. part 4		Q III Weekly quiz XI
20. Explain the application and use of Lamb waves	CT-6-4 pages 2-29 to 2-31		Q III Weekly quiz XI

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued)
(Flaw size determination)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 15. Explain transducer construction and relate it to beam	UTC by A. Struzyk page 23 CT-6-4 pages 3-12 and 3-13	Compare transducer types on known defects for:	T III Lab notebook Weekly quiz X
a) Single crystal geometry		a) Resolution b) Sensitivity	
b) T. R. probes	CT-6-4, 3-13 UTC by A. Struzyk pages 24 and 25	c) Sound beam penetration	T III Weekly quiz X
c) Special high temperature probes and techniques	UTC by A. Struzyk pages 26, 27, and 28		

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued)
(Angle beam refraction)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued)			
21. Relate part geometry to the resultant ultrasonic beam.	CT-6-4 pages 2-32 to 2-34	Ultrasonically test parts with known defects of different geometries.	T III
22. Relate mode conversion principles to specimen geometry.	CT-6-4 pages 2-34 to 2-36		

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued) (Resonance)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 23. Explain resonance thickness measurement and calculate thickness by resonance.	CT-6-4, pages 2-27 to 2-39		T III Weekly quiz XI

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TERMINAL OBJECTIVE: VII. Perform, interpret and evaluate an ultrasonic test. (continued)
(Equipment)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 24. Explain complex electronic adjustment of an ultrasonic instrument. a) Threshold b) Intensity c) Horizontal & vertical d) Sweep selector e) Astigmatism f) Damping g) Braod band and fixed frequency	CT-6-4 pages 3-3 to 3-6	Adjust ultrasonic unit during a test and observe effect on the test.	T III Lab notebook Weekly quiz XI
25. Identify types of ultrasonic scanning equipment a) A - scan b) B - scan c) C - scan	CT-6-4 pages 3-6 thru 3-9		T III
26. Explain the use of ultrasonic tanks in immersion testing and itentify a) Bridge b) Manipulators	CT-6-4 pages 3-11		T III

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TERMINAL OBJECTIVE: VII. Perform, evaluate and interpret an ultrasonic test. (continued)
(Equipment - continued)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 27. Identify types of transducers and explain the relative advantages of each. a) Barium titanite b) Lead metaniobate c) Lead zirconate d) Quartz e) Lithium sulfate f) X cut g) Y cut h) High frequency i) Low frequency j) Paint brush k) Single crystal l) Double crystal m) Straight beam n) Angle beam o) Immersion p) Contact q) Mini r) BNC s) Coaxial t) Cylindrically focused u) Spherically focused	CT-6-4 pages 3-15 to 3-20	Use as many different types of transducers as we have and compare unknown defects.	T III Lab notebook

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TERMINAL OBJECTIVE: VII. Perform, evaluate and interpret an ultrasonic test (continued)
(Equipment - continued)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 28. Explain the criteria for selection of a transducer a) Frequency selection b) Site selection c) Power selection	ASNT slide series on ultrasonic testing, part 5		T III Weekly quizzes
29. Explain the use of reference standards and calibration blocks in	CT-6-4, pages 3-20 thru 3-24	Test calibration blocks and relate to unknown defects.	T III Weekly quizzes Laboratory notebook
a) Angle beam b) Straight beam testing	Magnaflux ultrasonic work sheet series, pages 5 & 6		
Utilizing a) Alcou series A blocks b) Alcou series B blocks c) ASTN series d) IIW-std block e) IIW-field block			

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TERMINAL OBJECTIVE: VII. Perform, evaluate and interpret an ultrasonic test. (continued) (Specialized Techniques)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued) 30. Explain specialized techniques and their applications:	ASNT filmstrip series "Ultrasonic Testing", part 7		T III Weekly quizzes
a) High frequency immersion testing b) Bubbler technique c) Wheel transducer	CT-6-4, pages 4-5 thru 4-13		
31. Write an ultrasonic test procedure.	CT-6-4, pages 4-13 thru 4-28	Write a procudure on a part	Lab notebook

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TERMINAL OBJECTIVE: VII. Perform, evaluate and interpret an ultrasonic test. (continued) (Interpretation)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VII continued)			
32. Interpret test results	CT-6-4, pages 4-29 thru 4-41		Lab notebook
33. Explain transducer response checking and calibration.	CT-6-4, pages 6-3 thru 6-6 and 6-9 thru 6-12		
34. Explain the design parameters of angle beam transducers.	UTC by A. Struzyk pages 32-34		T III
35. Explain calibration of angle beam transducers.	UTC by A. Struzyk pages 35-37	Calibrate an angle beam	Lab notebook
36. Explain angle beam projection distance and relate it to sound path distance.	UTC by A. Struzyk pages 37-42		T III
37. Relate sound path distance to inspection of welds in angle beam testing.	UTC by A. Struzyk pages 42-46	Perform a weld ultrasonic examination	Lab notebook T III

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TERMINAL OBJECTIVE: VIII. Perform, interpret and evaluate an eddy current test. (Principles of eddy currents)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
1. Relate Faraday's law to formation of eddy currents.	CT-6-5, pages 3-3 thru 3-5		T IV and weekly quizzes
2. Explain how geometry of the coil and part affect eddy current.	CT-6-5, pages 3-4 thru 3-7		T IV and weekly quizzes
3. Explain how material properties affect eddy currents.	CT-6-5, pages 3-7 thru 3-10	Calibrate eddy current unit for testing conductivity	Lab notebook
4. How does lift off, and fill factor affect eddy currents.	CT-6-5, pages 3-11 and 3-12	Use eddy current unit to test non conductive coating	Text IV Weekly quiz Lab notebook
5. Relate frequency, penetration and standard depth of penetration.	CT-6-5, pages 3-13 to 3-14	Test for known defects at different depths and find detection limit.	Text IV Laboratory notebook Weekly quiz
6. Explain edge effect.	CT-6-5, page 3-15		Text IV Weekly quiz

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TERMINAL OBJECTIVE: VIII. Perform, interpret and evaluate an eddy current test. (continued) (Equipment)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VIII continued) 7. Explain the basic test circuit of an eddy current system.	CT-6-5, pages 4-3 and 4-4		Test IV Weekly quiz
8. Explain why bridge circuits are more sensitive than the basic test circuit.	CT-6-5, pages 4-5 thru 4-8		Test IV Weekly quiz
9. Define the different coils available and explain their advantages a) Surface probes b) Encircling coils c) Double coils d) Differential coils e) Self comparison f) External comparison	CT-6-5, pages 4-8 thru 4-16	Balance and test parts utilizing different coils.	Test IV Weekly quiz Lab notebook
10. Explain the use and advantages of (each) indicating device. a) Analog meters b) Digital meters c) Oscilloscope d) Strip chart recorders	CT-6-5, pages 4-16 thru 4-18		

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TERMINAL OBJECTIVE: VIII. Perform, interpret and evaluate an eddy current test. (continued)
(Evaluation and analysis)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(VIII continued)			
11. Explain impedance or amplitude testing.	CT-6-5, page 6-3	Set up an amplitude analysis test (eddy current)	Test IV Weekly quiz Lab notebook
12. Explain phase analysis and relate it to the complex plane diagram. a) Conductivity b) Lift off c) Frequency effect d) Thickness	CT-6-5, pages 6-4 thru 6-14	Set up a phase analysis test (eddy current)	Test IV Weekly quiz Lab notebook
13. Visualize the complex plane diagram to suppress irrelevant variables.	CT-6-5, page 6-15 thru 6-18	Take sample parts and suppress unwanted variables.	Test IV Weekly quiz Lab notebook
14. Relate the complex plane diagram to complex plane read-outs.	CT-6-5, pages 6-18 thru 6-21	Knowing the complex plane diagram, predict complex plane read-out on different parts.	Test IV Weekly quiz Lab notebook
15. Relate current applications in eddy current testing to a) Test rate b) Test complexity c) Equipment	CT-6-5, pages 6-25 thru 6-28		Test IV Weekly quiz

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TERMINAL OBJECTIVE: IX. Perform, interpret and evaluate radiographic examination. (Fundamentals)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
1. Explain how atoms are made up: a) Protoms b) Neutrons c) Electrons	Nondestructive testing "radiographic testing" CT 6-6, page 2-13		Test V Weekly quiz
2. Compare elements and isotopes: a) Stable elements b) Stable isotopes c) Unstable isotopes d) Half life	CT 6-6, pages 2-18 and 2-19 ASNT filmstrip series "Radiography" Introduction and part 1		Test V Weekly quiz

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TERMINAL OBJECTIVE: IX. Perform, interpret and evaluate a radiographic examination. (continued)
(The radiographic method)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 3. Explain how thickness via differential absorption is represented on radiographic film	CT 6-6, pages 2-3	Radiograph a step block showing changes of density with thickness	Test V
4. Explain how x and gama rays relate to the rest of the electromagnetic spectrum.	CT 6-6, pages 2-7 and 2-8		Test V Weekly quiz
5. Relate radiographic sensitivity to: a) Contrast b) Definition c) Penumbra d) Film speed and gram size	CT 6-6, pages 4-3, 4-4, 4-5, and 4-8	Take radiographs and examine for contrast, etc.	
6. Relate part geometry to distortion and fuzziness.	CT 6-6, pages 2-4, 2-5 and 2-6	Radiograph a flat plate weld and compare with a weld	Test V Weekly quiz Lab notebook
7. Explain the inverse square law.	CT 6-6, pages 2-10	Obtain proper film density.	Test V Weekly quiz

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TERMINAL OBJECTIVE: IX. Perform, interpret, and evaluate a radiographic examination. (Radiation)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
8. Classify different types of radiation: a) Alpha b) Beta c) Gamma and x-rays	CT 6-6, pages 2-17 and 2-18		Test V Weekly quizzes
9. Explain how radiation is measured (activity). a) Curie b) Specific activity c) Electron volt	ASNT Student Study Guide Section 5, pages 1-4 Section 4, pages 7-8		Test V
10. Compare radiation from isotopes with radiation from x-ray tubes.	CT 6-6, pages 2-11 and 2-12		Test V Weekly quiz
11. Explain how radiation quantity is described in quantity and energy.	Nuclear Reactor Engineering by Glasstone & Sesonski Pages 36-40		Test V Weekly quizzes
12. Explain how radiation interacts with matter absorption and scattering. a) Ionization	CT -6-6, pages 2-13 thru 2-15		Test V Weekly quizzes

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TERMINAL OBJECTIVE: IX. Perform, interpret and evaluate a radiographic examination. (continued)
(Radiation - continued)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) (12. continued) b) Photelectric absorpsion c) Compton scattering d) Pair production e) Scatter radiation f) Bremsstrahlung radiation	ASNT filmstrip series Part 2, Radiography		
13. Explain how shielding works and relate sheilding to half value thickness.	CT 6-6, pages 5-9, 5-11	Calculate half value layer for lead sheet using known radiation source and thin lead screens.	Test V Weekly quizzes Lab notebook
14. Explain neutron radiation and neutron radiography	Nuclear Reactor Engineering by Glasstone and Sesonske pages 56-59 ASNT Student Study Guide section 5, page 9		Test V Weekly quizzes

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TERMINAL OBJECTIVE: IX. Perform, interpret and evaluate a radiographic examination. (continued) (X-ray equipment)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 15. Explain the functioning of an x-ray tube. (How does it work?)	CT 6-6, pages 3-3 thru 3-6		Test V Weekly quizzes
16. Relate the functioning of the x-ray tube to the spectrum of energies emitted (characteristic x-rays).	CT 6-6, pages 3-6 and 2-11		
17. Relate the x-ray tube functioning to sharpness via beam configuration.	CT 6-6, pages 3-6 thru 3-9		Test V Weekly quizzes
18. Explain the different types of x-ray tubes and the advantages of the different types a) Self rectification b) Separate rectified c) Beta tron accelerators d) Linear accelerators	ASNT NDT filmstrip series part 3	Take radiographs of known defective parts.	Test V Lab notebook
19. Compare gama ray sources to x-ray tubes.	CT 6-6, pages		

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, interpret and evaluate a radiographic examination. (continued)
(Gamma ray equipment)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 20. Calculate exposure by isotopes: a) Activity b) Equilivant c) Half life	CT 6-6, pages 3-14 thru 3-16	Calculate exposure factors for making a radiograph by sources.	Lab notebook Test V
21. Explain how source radiation is minimized by use of remote handling equipment.	CT 6-6, pages 3-17 thru 3-19		Test V Weekly quizzes

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, evaluate and interpret a radiographic examination. (continued)
(Contrast and latitude)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 22. Explain the importance of contrast and latitude in radiography.	CT 6-6, pages 4-3 thru 4-5		Test V Weekly quizzes
23. Apply H-D curves and exposure charts for proper contrast.	CT 6-6, pages 4-5 thru 4-7		Test V Weekly quizzes
24. Explain darkroom layout and equipment.	CT 6-6, pages 4-14 thru 4-17	Evaluate laboratory darkroom	Lab notebook Test V Weekly quizzes
25. Relate components of film to chemical changes during darkroom processing.	CT 6-6, pages 4-9 thru 4-14		Test V Weekly quiz

COURSE NO. 470-312

PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION

INSTRUCTION PLAN

INSTRUCTOR D. Faull

DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, evaluate and interpret a radiographic examination. (continued) (Film Processing)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 26. Relate film sharpness to film speed.	CT 6-6, pages 4-8		Test V Weekly quiz
27. Define the relationship of processing temperature, time and replenishing cycles to radiographic quality.	Kodak Guide to photographic processing.	Take a sample radiograph and develop at different times and temperatures.	Lab notebook
28. Define the chemicals used in darkroom processing: a) Developer b) Stop c) Fixer d) Photo phlo	CT 6-6, pages 4-15		Test V Weekly quiz
29. Explain how film processing defects occur and how they can be avoided.	ASNT filmstrip series, part 6 "Radiography"		Test V Weekly quiz

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, evaluate, and interpret a radiographic examination. (continued)
(Radiation safety)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 30. Explain how radiation damages body tissues by ionization. a) Cell structure b) DNA	CT 6-6, pages 5-3		Test V Weekly quiz
31. Explain the differences in being exposed to x-rays and exposure to radiographic contaminants.	ASNT Student Handbook Lesson 10, page 3		Test V Weekly quiz
32. Explain the differences and hazards of internal and external radiation.	ASNT Student Handbook Lesson 10, page 2		Test V Weekly quiz
33. Define: Rontgen RAD RBE REM	CT 6-6, page 5-4		Test V Weekly quizzes
33. Explain U.S. NRC dose limits of radiation and relate them to changes in time, age, sex.	Code of Federal Regulations title 10, chapter 1, parts 20, 30, and 31		Test V

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform evaluate, and interpret a radiographic examination. (continued)
(Radiation safety - continued)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 35. Rate cells in the body according to radioactive sensitivity and explain which effects are somatic genetic	SDNT filmstrip series "Radiography", part 5 Safety		Test V Weekly quiz
36. Explain somatic and genetic effects of radiation and how the latent period changes for each.	CT 6-6, pages 5-13 thru 5-18		Test V Weekly quiz

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, evaluate and interpret a radiographic examination. (continued)
(Radiation measurement)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued)			
37. Explain the theory and use of personal monitoring devices and how each is used. a) Pocket dosimeter b) Film badge	CT 6-6, pages 5-20 thru 5-22	Use sample personal radiation devices and show radiation levels around the x-ray tube room.	Test V Lab notebook
38. Explain the theory and use of survey meters. a) Geiger-Mueller tubes b) Ion chambers C) Area alarm systems	CT 6-6, pages 5-23 thru	Use radiation instruments around the laboratory. Test for leakage from the x-ray room.	Lab notebook
39. Perform dose rate calculations using a) Time b) Distance c) Shieldin g	CT 6-6, pages 5-7 thru 5-8	Design a safe containment area for a linear accelerator.	Test V Lab notebook

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN

DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, evaluate and interpret a radiographic examination. (continued)
(Other radiographic equipment)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued 40. Explain the use and function of Lead foil Florescent Flourmetallic intensifying screens.	CT 6-6- pages 6-4 thru 6-10	Utilize different intensifying screens on radiograph and note.	Lab notebook Test V
41. Explain how penetrometers monitor sensitivity.	CT 6-6, pages 6-10 thru 6-12	Read penetrometers on radiographs showing sensitivity.	Test V Weekly quiz
42. Explain how masking is used to sharpen the radiographic image.	CT 6-6, page 6-11		Test V

COURSE NO. 470-312 PRECISION INSPECTION AND NON-DESTRUCTIVE EXAMINATION INSTRUCTOR D. Faull

INSTRUCTION PLAN DATE 05-19-82

TERMINAL OBJECTIVE: IX. Perform, evaluate and interpret a radiographic examination. (continued)
(Fundamental radiographic relationships)

LEARNING OUTCOMES	CLASSROOM ACTIVITY AND RESOURCES	LABORATORY ACTIVITY AND RESOURCES	EVALUATION
(IX continued) 43. Relate a) Thickness b) Miliampere-minutes c) Target to film distance d) Film e) Processing conditions to film density.	CT 6-6, pages 6-15 thru ASNT filmstrip "Radiography", part 7	Shoot a radiograph with each of these variables showing fundamental relationships.	Test V
44. Explain how the exposure factor is used to obtain radiographic consistancy.	CT 6-6, pages 6-34 thru 6-44		Test V

Equipment

Northeast Wisconsin Technical Institute has a wide range of equipment available for student use. Included is a complete dye penetrant system, URESCO Model UPE-101; magnetic particle unit, URESCO Model 3505; two portable magnetic particle units; six ultrasonic unit; two eddy currents; one thickness guage; 300 k VA Phillips x-ray unit; complete darkroom facilities; Model 750 Mark II Jarrell-Ash spectrometer; Laser Technology Holomatic 600D System; complete metallurgical laboratory and a complete precision inspection laboratory. The testing facility at Northeast Wisconsin is used as a a weld test center for the State of Wisconsin where welders are qualified to AWS, ASME, and other codes. Northeast Wisconsin also cooperates with the Northeast Wisconsin Chapter of ASNT in conducting seminars to meet special needs of the community.

Faculty

There are two instructors assigned to teach in this program. One is a metallurgical engineer in non-destructive testing. The second has a math backgound and has worked in industry doing inspection of materials. Students spend 20 hours a week with one of these major instructors. The rest of the time is spent with other faculty at the institute who teach the other courses listed in the curriculum.

Placement

Most graduates are employed although there is limited employment potential in the immediate area. Many of the graduates are employed in larger cities such as Minneapolis and Chicago, and in the construction industry in the Southwest part of the country. Some graduates have gone on for other degrees in related programs. The average starting salary is $7.17 per hour.

Future Trends

In the near future, a computer (Hewlett Packard) will be added to the coordinate measuring machine. Other additions to the program include acoustic emission testing equipment and laser applications for automatic measurements.

PROGRAM: Geo-Metrics Course
INSTITUTION: Lakeshore Technical Institute
1290 North Avenue
Cleveland, Wisconsin 53015
(414) 693-8211
CONTACT PERSON(S): Robert Moore or William Jaeger
This is a one-credit course (30 hours of class time)
COURSE STARTED: 1978

Definition

What is Geometric Tolerancing?

Geometric dimensioning and tolerancing is a means of specifying engineering design and drawing requirements with respect to actual "function" and "relationship" of part features. Furthermore, it is a technique which, when properly applied, ensures the most economical and effective production of the features. Geometric dimensioning and tolerancing can thus be considered both an engineering design drawing language and a functional production and inspection technique. Uniform understanding and interpretation among design, production, and inspection groups are the major objectives of the system.

Why use Geometric Tolerancing?

The American National Standards Association has adopted geo-tolerancing as the standard. It is an international "language" which allows accurate communication within an agreed upon framework. It is more accurate than conventional dimensioning. For example, geometric tolerancing uses a round tolerance zone for round holes instead of square tolerance zones. Geometric tolerancing always indicates what datum reference should be used when measuring. This eliminates the inconsistancies caused by the arbitrary choices of references in conventionl dimensioning.

The key to geometric tolerancing is funtional tolerancing. The fact that measurements begin at the functionally most important feature of a part, makes geometric tolerancing the blueprint equivalent of functional gaging. It also serves to increase productivity by saving time and material lost to inconsistancy and ineffective measuring techniques.

Who is using Geometric Tolerancing?

Companies such as General Motors, Honeywell, Chrysler, Xerox, Allis-Chalmers, IBM, AMF, John Deer and Ford Motor Company are using geometric tolerancing. Others are also adapting the system.

History

This course was first offered in 1978. A need was expressed by local industry for training. The company wanted to retain their employees but wanted outsiders to teach the course. Therefore, they went to Lakeshore Technical Institute for the expertise. The instructors worked with one local company and set-up the course experimentally.

Since that time, the needs have expanded. The Society for Manufacturing Engineers saw a need for change in the training of those working in all manufacturing concerns.

The Course

When the material was first integrated into the Mechanical Design program, it was integrated into an already existing curriculum. Three years ago, it was acknowledged that more time and attention had to be allotted to the subject matter. As a result, a separate one-credit course was established.

Currently there are three different courses offered. One is for full-time mechanical design students. The other two are taught to employees who are sent by their employers to learn about Geo-metrics. One of these courses lasts five weeks (no credits) and is designed to teach symbols and interpret drawings. The third course is also offered to local employers but is a one-credit course designed for engineers. It is offered as an evening course.

The course is a lecture course. The information is then integrated into other laboratory courses that are required for full-time students in the Mechanical Design program. Laboratories which use applications of geometrics include Design Problems, Tool Design, and Working Drawings.

An outline of the one-credit course follows.

Lakeshore Technical Institute
Mechanical Design Dept.

Course#: 606-106
Title: Geo-Metrics
Length: 30 Hours

Objective: This course is designed to introduce the individual working in an engineering department to the concepts of tolerancing geometry separately from size, and to use positional tolerancing for locating part features.

Topical Outline

I. General Rules of Dimensioning
   A. Past practices
   B. 1973 edition of ANSI stds.
   C. 1982 edition of ANSI stds.

II. Form Tolerancing

   A. Individual
      1. flatness
      2. straightness
      3. roundness
      4. cylindricity
   B. Individual or related
      1. profile of a line
      2. profile of a surface
   C. Related
      1. perpendicularity
      2. angularity
      3. Parallelism
      4. runout
         a. circular
         b. total

III. Position

   A. Theory
   B. Mating parts
      1. floating fastener
      2. fixed fastener
   C. Composite
   D. Datums
      1. implied
      2. specified
      3. targets

IV. Concentricity

    A. Theory
    B. Use

V. Symmetry

    A. Theory
    B. Use of position instead

VI. Applications

Equipment

Equipment consists of slides and books. All applications of geometrics are done in an already existing laboratory.

Faculty Development

There are two full-time faculty who are involved with the teaching of the course. They, of course, have other responsiblities in the program. The school initially sent them to seminars to gain expertise in the area. The school still sends them for one week training update seminars so that the program can be kept current with industry needs.

Placement

Since the program is a one-credit course, it is difficult to say if it has affected placment one way or the other. It is very clear that the advisory committee wants the course to be an integral part of the Mechancial Design program. More companies are going to this system. Therefore, it gives graduates an obvious advantage when applying for a job with a company that is currently using geometric dimensioning and tolerancing.

Appendix A

Examples of Programs Impacted by Technology and High Technology - Completed by the Minnesota State Department of Education

- Agri-Business/Natural Resources
    - Agri-Business Office Services
    - Agricultural Supplies Technology
    - Agricultural Finance Officer
    - Dairy Herd Management
    - Commercial Greenhouse Crop Production
    - Farm Equipment Mechanics
    - Horticulture Aide
    - Landscape Technology
    - Natural Resources
    - Production Agriculture
    - Soil Management and Fertilizer Technology

- Business/Office
    - Accounting and Accounting Clerk
    - Administrative Secretary
    - Banking and Financce
    - Bookkeeping and Bookkeeping Clerk
    - Clerical/Office Assistant
    - Computer Operator
    - Computer Programming
    - Court Reporter
    - Data Entry Operation/Keypunch
    - General Secretarial
    - Materials Management
    - Medical Clerk
    - Office Management
    - Office Services Aide
    - Property and Facilities Management
    - Receptionist
    - Sales and Management
    - Word Processing

- Communications/Media
    - Advertising, Display and Sales
    - Advertising Layout
    - Crafting
    - Commercial Photography
    - Graphic Arts
    - Media Production
    - Phototypesetting
    - Slide Production
    - Technical Art and Illustration
    - Telephone Communications Technician
    - Telephone Electronics Technician
    - Video Production

- Construction
  - Agriculture Building Construction
  - Bricklaying
  - Building Construction
  - Cabinetmaking
  - Carpentry
  - Construction Technology
  - Electrical
  - Heating and Air Conditioning Service
  - Industrial Welding
  - Metal Fabrication
  - Painting and Decorating
  - Plumbing
  - Sheet metal
  - Surveying Technology

- Environmental
  - Air and Water Analysis Technology
  - Chemical Technology
  - Environmental-Chemical Technology
  - Forest Harvesting Technician
  - Water and Wastewater Treatment Technology

- Health
  - Bio-Medical Equipment Technician
  - Central Service Technician
  - Dental Assisting
  - EEG Technician
  - Hospital Pharmacy Technician
  - Hospital Unit Assistant
  - Medical Lab Technician
  - Medical Records Technician
  - Nursing Assistant
  - Occupational Therapy Assistant
  - Optical Technology
  - Orthotics Technician
  - Practical Nursing
  - Respiratory Therapy Technician
  - Ward Clerk

- Marketing
  - Building Materials Sales
  - Commercial Art
  - Credit Management
  - Distribution Center/Warehousing Training
  - Fashion Merchandising
  - Home Furnishing Sales
  - Interior Design and Sales
  - Marketing and Merchandising Management
  - Practical Business Management
  - Professional Sales
  - Purchsing and Inventory Management
  - Real Estate Sales

- Marketing (Continued)
    - Retail Floristry
    - Sales Associate
    - Small Business Management
    - Travel Planner

- Personal Services
    - Barbering
    - Commercial Banking
    - Cook/Chef
    - Cosmetology
    - Food Preparation Technology
    - Food Service and Management
    - Law Enforcement
    - Restaurant and Hotel Managmeent

- Technical and Manufacturing
    - Appliance Repair
    - Automated Packaging Machinery Technology
    - Building Equipment Maintenance
    - Business and Office Machine Technician
    - Cable Television Technician
    - Electro-Mechanical Technology
    - Fluid Power Technology
    - Industrial Engineering Technology
    - Industrial Machine Mechanic
    - Instrumentation Technology
    - Laser Electro-Optic Technology
    - Machinist
    - Numerical Control Technician
    - Quality Control
    - Service Electronics
    - Tool, Die and Moldmaking
    - Welding and Metal Fabrication

- Transportation/Mechanical
    - Air Traffic Control
    - Avionics
    - Bus/Truck Mechanics
    - Electrical Maintenance
    - Heavy Equipment Operations and Maintenance
    - Industrial Equipment Mechanics
    - Parts Manager
    - Service Station Sales and Repair
    - Truck and Diesel Mechanics

(For a complete report, contact the Minnesota State Department of Education.)

Appendix B

Appendix B contains information about existing High Technology programs in Vocational Education.

The appendix contains two sections. Appendix B-1 is organized by program area. States where the programs are operating are listed under each program area.

Appendix B-2 is organized by state. Within each state, programs, locations and contact persons are listed.

(Note: This appendix only includes those programs listed during a 1983 survey of State Departments of Education.)

Appendix B-1

Biomedical

Alabama
Georgia
Indiana
Maine
Massachusettes
Ohio
Tennessee
Wisconsin

Computer-Assisted Design (CAD)

Alabama
Arkansas
Florida
Georgia
Illinois
Maine
Minnesota
Mississippi
New Mexico
New York
Ohio
Oklahoma
Oregon
Tennessee
West Virginia
Wisconsin

Computerized Numerical Control (CNC)

Alabama
Arkansas
Mississippi
Oklahoma
West Virginia
Wisconsin

Information Processing

Arkansas
Florida
District of Columbia
Hawaii
Idaho
Massachusetts
Minnesota
Mississippi
New York
Ohio
Oklahoma
South Carolina
Tennessee
Wisconsin

Laser-Optic Technology

Georgia
Indiana
Minnesota
Mississippi
New Mexico
Ohio
Oklahoma
Wisconsin

Manufacturing & Service Technologies

Alabama
Arkansas
Florida
Georgia
Hawaii
Idaho
Indiana
Maine
Massachusetts
Minnesota
Mississippi
New York
Ohio
Oklahoma
Tennessee
West Virginia
Wisconsin

Robotics

Arkansas
Florida
Georgia
Indiana
Kentucky
Massachusettes
Minnesota
Mississippi
New York
Oregon
Tennessee
West Virginia
Wisconsin

Telecommunications

Alabama
Florida
Minnesota

Miscellaneous

Architectural Technology - New York

Audio Technology - Indiana

Aviation Technology - Alabama

Avionics Technology - Georgia
New York

Chemical Technology - New York
Tennessee

Communications - Georgia

Computer Programmer Technology - Massachusettes

Construction Technology - Wisconsin

Diesel Power Technology - Indiana

Electronic Design & Packaging - Wisconsin

Engineering Graphics - Tennessee

Geometric Tolerancing - Wisconsin

Hazardous Waste Control - Maine

Hydraulics - Maine

Industrial Packaging & Quality Control Technologies - Ohio

Oil Field Technology - New Mexico

Optical Lab Technician - Alabama

Precision Inspection Material Examination - Wisconsin

Quality Assurance - Wisconsin

Radiologic Technology - Arkansas

Refrigeration & Air Conditioning - Maine

Technical Writer - Massachusettes

Thermo Dynamics - Tennessee

Tool & Die Making Technology - Mississippi

Visual Communication Equipment - Minnesota

Water Utilities Technology - New Mexico

Welding - Maine

Appendix B-2

Alabama

Aviation Technology

Alabama Aviation & Tech. Col.
P.O. Box 1088
Ozark AL 36360
(205) 774-5113

Bio Medical Equipment Technician

RTI for Health Occupations — Mr. Bob Heacock
Birmingham Medical Technical Prog.
School of Comm.& Allied Health
University of Alabama, Birmingham
University Station
Birmingham AL 35294
(205) 934-3648

Drafting

Alabama Technical College
1001 East Broad St.
Gadsden AL 35903
(205) 547-5451

Harry M. Ayers State Tech. Col.
P.O. Box 1647
Anniston AL 36201
(205) 831-4540

Bessemer State Tech. Col.
P.O. Box 308
Bessemer AL 35021
(205) 428-6391

John C. Calhoun State Comm. Col.
P.O.Box 2216
Decatur AL 35602
(205) 353-3102

J. F. Drake State Technical College
3421 Meridian Street, North
Huntsville AL 35811
(205) 539-8161

C. A. Fredd State Technical College
3401 32nd Avenue
Tuscaloosa AL 35401
(205) 752-9738

Alabama
Drafting (continued)

Richmond P. Hobson State Tech. Col.
P.O. Box 729
Thomasville AL 36784
(205) 636-4429

T. A. Lawson State Community College
3060 Wilson Road SW
Birmingham AL 35221
(205) 925-1666

Douglas MacArthur State Tech. Col.
P.O. Box 649
Opp AL 36467
(205) 493-6631

Muscle Shoals State Tech. Col.
P.O. Box 2545
Muscle Shoals AL 35660
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N. F. Nunnelley State Tech. Col.
P.O. Box 389
Childersburg AL 35044
(205) 378-5576

Opelika State Technical College
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Opelika AL 36801
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Ed. E. Reid State Technical College
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Shelton State Technical College
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Tuscaloosa AL 35401
(205) 556-1165

Southwest State Technical College
925 Dauphin Island Parkway
Mobile AL 36605
(205) 479-7476

Chauncey Sparks State Technical Col.
P.O. Box 56
Eufaula AL 36027
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Alabama
Drafting (continued)

Councill Trenholm State Tech. Col.
1225 Air Base Boulevard
Montgomery AL 36108
(205) 264-8426

Walker State Technical College
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Sumiton AL 35148
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George C. Wallace State Comm. Col.
Napier Field
Dothan AL 36301
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George C. Wallace State Comm. Col.
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Electronics

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Alabama
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(205) 288-1080

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Shelton State Technical College
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Instrumentation Technology

Southwest State Technical College
925 Dauphin Island Pkwy.
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(205) 479-7476

Machine Shop

Alabama Technical College
1001 East Broad Street
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Harry M. Ayers State Tech. Col.
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Muscle Shoals AL 35660
(205) 381-2813

Northwest Alabama State Tech. Col.
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Hamilton AL 35570
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Alabama
Machine Shop (continued)

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George C. Wallace State Comm. Col.
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(205) 352-6403

Numerical Control

Shelton State Technical College
Drawer J. East Side Station
Tuscaloosa AL 35401
(205) 566-1165

Alabama
Optical Lab Technician

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(205) 831-4540

Mr. Pierce Cain, Pres.

Telecommunications

Gadsden State Tech. Inst.
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Gadsden AL 35901
(205) 547-1685

Mr. George Beaube,
Dean of Instruction

Arkansas

Automated Word Processing

Garland County Community College
#1 College Drive
Hot Springs AR 71901

Computer Assisted Design (CAD)/Drafting

Statewide

Charles Easley
Voc. & Tech. Educ. Div.
Dept. of Ed., Cap. Mall
Little Rock AR 72201

Computer Numerical Control (CNC)

Statewide

Charles Easley
Voc. & Tech. Educ. Div.
Dept. of Ed., Cap. Mall
Little Rock AR 72201

Computer Science

Arkansas Valley Vo-Tech
P.O. Box 506
Ozark AR 72949

Electromechanical Technology

Twin Lakes Vo-Tech
P.O. Box 1496
Harrison AR 72601

Arkansas

Instrumentation Technology

Pulaski Vo-Tech
3000 West Scenic Drive
No. Little Rock AR 72118

Phillips County Comm. College
Box 785
Helena AR 72342

Radiologic Technology

Phillips County Community College
Box 785
Helena AR 72342

Robotics & Manufacturing

Southern Arkansas University
P.O. Box3048
East Camden AR 71701

District of Columbia

Accounting (Using Microcomputers)

Chamberlain Career Center
14th & Potomac Streets, S.W.
Washington DC 20003
(202) 724-4648

Ruby Burgin

Business Data Processing & Computer Technology

Burdick Career Center
1300 Allison Street, N.W.
Washington DC 20011
(202) 576-6241

Thelma Randall
Christine Easterling

Court & Conference Reporting

Burdick Career Center
1300 Allison Street, N.W.
Washington DC 20011
(202) 576-6241

Geraldine Alexander

District of Columbia

Medical Records

M. M. Washington Career Center Aloha Cobb
27 "O" Street, N.W.
Washington DC 20001
(202) 673-7224

Medical Transcription

M. M. Washington Career Center Aloha Cobb
27 "O" Street, N.W.
Washington DC 20001
(202) 673-7224

Medical Secretarial

M. M. Washington Career Center Aloha Cobb
27 "O" Street, N.W.
Washington DC 20001
(202) 673-7224

Word Processing Specialist

Burdick Career Center Geraldine Hall
1300 Allison Street, N.W.
Washington DC 20011
(202) 576-6241

Chamberlain Career Center Joyce Perkinson
14th & Potomac Streets, S.W.
Washington DC 20003
(202) 724-4648

Florida

Allied Health

Broward Comm. Col. Central Campus Dr. Mehallis
3501 Southwest Daire Road
Ft. Lauderdale FL 33314

Computer Science

Broward Comm. Col. Central Campus
3501 Southwest Daire Road
Ft. Lauderdale FL 33314

Florida

Data Processing

Broward Comm. Col. Central Campus   Dr. Mehallis
3501 Southwest Daire Road
Ft. Lauderdale FL 33314

Sante Fe Community College
3000 Northwest 83rd Street
Gainesville FL 32602

Seminole Community College
Sanford FL 32771

Drafting and Design

Broward Comm Col. Central Campus
3501 Southwest Daire Road
Ft. Lauderdale FL 33314

Electromechanical Technology

Brevard Community College
1519 Clearlake Road
Cocoa FL 32922

Pinellas Vo-Tech Institute   Warren Laux, Director
6100 154th Avenue, N.
Clearwater, FL 33520
(813) 531-3531

Electronic Office

Broward Comm. Col. Central Campus   Dr. Mehallis
3501 Southwest Daire Road
Ft. Lauderdale FL 33314

Electronics

Broward Comm. Col. Central Compus   Dr. Oppenheimer
3501 Southwest Daire Road
Ft. Lauderdale, FL 33314

Valencia Comm. Col.   Harvey Salz
P.O. Box 3028
Orlando FL 32802

Santa Fe Community College   Don Dekold
3000 Northwest 83rd. Street
Gainesville FL 32602

Florida

Electronics Technology

Seminole Comm. Col. Sanford FL 32771	Dr. Paul Bordenkircher
Broward Comm. Col. Central Campus 3501 Southwest Daire Road Ft. Lauderdale FL 33314	Burton Greenstein

Engineering Technology

Broward Comm. Col. Central Campus 3501 Southwest Daire Road Ft. Lauderdale FL 33314	Dr. Neil Lash

Hybrid Microelectronics

Valencia Community College P.O. Box 3028 Orlando FL 32802	Harvey Salz

Industrial Electronics

Seminole Community College Sanford FL 32771	Donald Embree
Sante Fe Comm. Col. 3000 Northwest 83rd Street Gainesville FL 32602	Don Dekold
Brevard 1519 Clearlake Road Cocoa FL 32922	

Robotics

Broward Comm. Col. Central Campus 3501 Southwest Daire Road Ft. Lauderdale FL 33314	Dr. Mehallis

Telephone Technology

Seminole Community College Sanford FL 32771	

Word Processing/Office Information Processing

Broward Comm. Col. Central Campus 3501 Southwest Daire Road Ft. Lauderdale FL 33314	Dr. Mehallis

Florida
Word Processing (Continued)

Sante Fe Comm. Col.
3000 Northwest 83rd Street
Gainesville FL 32602

Seminole Comm. Col.
Sanford FL 32771

Georgia

Avionics

Savannah Area Voc-Tech School 5717 White Bluff Road Savannah GA 31401 (912) 352-1454	Roert A. Young, Dir.

Bio-Medical Technology

Under Devleopment	Dr. R. E. Morrison, Jr. High Tech. Coordinator Voc/Tech Ed. 1766 Twin Towers East Atlanta GA 30334

Communications

Augusta Area Voc-Tech School 3116 Dean Ridge Road Augusta GA 30906 (404) 798-4343	Jack Patrick, Dir.
Columbus Area Voc-Tech School 928 - 45th Street Columbus GA 31904 (404) 322-1425	W. G. Hartline, Dir.
Dekalb Area Voc-Tech School 495 North Indian Creek Drive Clarkston GA 30021 (404) 299-4000	Dr. Paul Starnes, Dir.
Marietta-Cobb Area Voc-Tech School 980 South Cobb Drive Marietta GA 30060 (404) 422-1660	L. L. Leverette, Dir (404) 422-1662
Savannah Area Voc-Tech School 5717 White Bluff Road Savannah GA 31401 (912) 352-1454	Robert A. Young, Dir.

Georgia

Computer Applications

Athens Area Voc-Tech School
U.S. Highway 29 North
Athens GA 30601
(404) 549-2360
Robert G. Shelnutt, Dir.
(404) 353-1664

Augusta Area Voc-Tech School
3116 Dean Ridge Road
Augusta GA 30906
(404) 798-4343
Jack Patrick, Dir.

Columbus Area Voc-Tech School
928 - 45th Street
Columbus GA 31904
(404) 322-1425
W. G. Hartline, Dir.

Dekalb Area Voc-Tech School
495 North Indian Creek Drive
Clarkston GA 30021
(404) 299-4000
Dr. Paul Starnes, Dir.

Marietta-Cobb Area Voc-Tech School
980 South Cobb Drive
Marietta, GA 30060
(404) 422-1660
L. L. Leverette, Dir.
(404) 422-1662

Savannah Area Voc-Tech School
5717 White Bluff Road
Savanna GA 31401
Robert A. Young, Dir.

Computer Numerical Control (CNC) Machining

Atlanta Area Vo-Tech School
1560 Stewart Avenue S.W.
Atlanta GA 30310
(404) 758-9451
Betty Campbell, Dir.
(404) 755-2019

Electrical Technology (EMET)

Augusta Area Voc-Tech School
3116 Dean Ridge Road
Augusta GA 30906
(404) 798-4343
Jack Patrick, Dir.

Columbus Area Voc-Tech School
928 - 45th Street
Columbus GA 31904
(404) 322-1425
W. G. Hartline, Dir.

Marietta-Cobb Area Voc-Tech School
980 South Cobb Drive
Marietta GA 30060
(404) 754-2131
L. L. Leverett, Dir.
(404) 422-1662

Georgia
Electrical Technology (EMET) (continued)

Savannah Area Voc-Tech School
5717 White Bluff Road
Savannah GA 31401
(912) 352-1464
Robert A. Young, Dir.

Electromechanical Technology

Marietta-Cobb Area Voc-Tech School
980 South Cobb Drive
Marietta GA 30060
(404) 422-1660
L. L. Leverette, Dir.
(404) 422-1664

Industrial Electronics

Columbus Area Voc-Tech School
928 - 45th Street
Columbus GA 31904
(404) 322-1425
W. G. Hartline, Dir.

Marietta-Cobb Area Voc-Tech School
980 South Cobb Drive
Marietta GA 30060
(494) 422-1660
W. W. Hobbs, Dir.
(404) 422-1662

Instrumentation and Industrial Control

Augusta Area Voc-Tech School
3116 Dean Ridge Road
Augusta GA 30906
(404) 798-4343
Jack Patrick, Dir.

Columbus Area Voc-Tech School
928 - 45th Street
Columbus GA 31904
(404) 322-1425
W. G. Hartline, Dir.

Marietta-Cobb Area Voc-Tech School
980 South Cobb Drive
Marietta GA 30060
(404) 422-1660
L. L. Leverette, Dir.
(404) 422-1664

Laser Optics Technology

Under Development

Dr. R. E. Morrison, Jr.
High Tech. Coordinator
Voc/Tech Ed.
1766 Twin Towers East
Atlanta GA 30334

Georgia
Mechanical Engineering Technology (Design or CAD)

Athens Area Voc-Tech School
U.S. Highway 29 North
Athens GA 30601
(404) 549-2360
Robert G. Shelnutt, Dir.
(404) 353-1664

Augusta Area Voc-Tech School
3116 Dean Ridge Road
Augusta GA 30906
(404) 798-4343
Jack Patrick, Dir.

Columbus Area Voc-Tech School
928 - 45th Street
Columbus GA 31904
(404) 322-1425
W. G. Hartline, Dir.

DeKalb Area Voc-Tech School
495 North Indian Creek Drive
Clarkston GA 30021
(404) 299-4000
Dr. Paul Starnes, Dir.

Marietta-Cobb Area Voc-Tech School
980 South Cobb Drive
Marietta GA 30060
(404) 422-1660
L. L. Leverette, Dir.
(404) 422-1662

Savannah Area Voc-Tech School
5717 White Bluff Road
Savannah GA 31401
(912) 352-1464
Robert A. Young, Dir.

Mechanical Engineering Technology (Production or CAM)

Athens Area Voc-Tech School
U.S. Highway 29 North
Athens GA 30601
(404) 549-2360
Robert G. Shelnutt, Dir.

Augusta Area Voc-Tech School
3116 Dean Ridge Road
Augusta, GA 30906
(404) 798-4343
Jack Patrick, Dir.

Columbus Area Voc-Tech School
928 - 45th Street
Columbus GA 31904
(404) 322-1425
W. G. Hartline, Dir

DeKalb Area Voc-Tech School
495 North Indian Creek Drive
Clarkstone GA 30021
(404) 299-4000
Dr. Paul Starnes, Dir.

Georgia
Mechanical Engineering Technology (Production or CAM) (Continued)

Marietta-Cobb Area Voc-Tech School 980 South Cobb Drive Marietta GA 30060 (404) 422-1660	L. L. Leverette, Dir. (404) 422-1662
Savannah Area Voc-Tech School 5717 White Bluff Road Savannah GA 31404 (912) 352-1464	Betty Campbell, Dir.

Robotics

Athens Area Voc-Tech School U.S. Highway 29 North Athens GA 30601 (404) 549-2360	Robert G. Shelnutt, Dir.
Augusta Area Voc-Tech School 3116 Dean Ridge Road Augusta GA 30601 (404) 798-4343	Jack Patrick, Dir.
Columbus Area Voc-Tech School 928 - 45th Street Columbus GA 319043 (404) 299-4000	W. G. Hartline, Dir.
DeKalb Area Voc-Tech School 495 North Indian Creek Drive Clarkston GA 30021 (404) 422-1660	Dr. Paul Starnes, Dir.
Marietta-Cobb Area Voc-Tech School 980 South Cobb Drive Marietta GA 30060	L. L. Leverette, Dir. (404) 422-1662
Savannah Area Voc-Tech School 5717 White Bluff Road Savannah GA 31401 (912) 352-1464	Robert A. Young, Dir.

Hawaii

The following programs and curricula are offered by the Honolulu Community College.

Electrical/Electronics

Curricula:
- Biomedical
- Electrical Communications
- Engineering Aide
- Industrial Electronics

Business/Distributive

Curricula:
- Computer Operator
- Data Entry
- Data Processing
- Data Processing Operations

For more information contact:

Dr. William Broadbent
Chancellor for the Community Colleges
Occupational Development
Department of Education
Hawaii
(808) 948-7461

Idaho

Data Processing

Area Vocational Technical School Pocatello ID 83209	Mr. Clarence Haught Coeur d'Alene ID 83814

Industrial Electronics

Area Vocational Technical School Pocatello ID 83209	Mr. Ernie Dahlquist

Illinois

Computer Assisted Drafting & Design

Indian Valley Vocational Center
Sandwich IL 60548

Mark Schwendau
600 Lions Road
Sandwich IL 60548

Indiana

Audio Technology

Occupational & Technical Programs
Smith Research Center
Indiana University
Bloomington IN 47405

Dr. Robert Harris

Biomedical Electronics Technology

School of Technology
South Campus Courts - A
Purdue University
West Lafayette IN 47907
(317) 494-1101

Dr. George McNelly, Dean

Computer/Robotics Service Technology

Evansville-Vanderburgh School Corp.
1 S.E. 9th Street
Evansville IN 47708
(812) 426-5039

John Clerk, Dir. of Practical Arts, Vocational and Adult Education

Diesel Power Technology

Indiana Voc-Tech College
646 Franklin Street
Columbus IN 47201

Harvey S. Poling,
Vice President/Dean

Electronics

Indiana Voc-Tech College
1440 East 35th Avenue
Gary IN 46409
(219) 981-1111

Donald P. Belec,
Vice Presidnet/Dean

Indiana Voc-Tech College
First and Broadway Streets
Madison IN 47250
(812) 265-2579

Homer B. Smith

Indiana
Electronics (continued)

Indiana Voc-Tech College
2325 Chester Boulevard
P.O. Box 1145
Richmond IN 47374
(317) 966-2656

Norman Sievert

Electronics Technology-Industrial Electronics Option

Indiana Voc-Tech College
8204 Highway 31 West
Sellersburg IN 47172

Carl F. Scott,
Vice President/Dean

Instrumentation

Indiana Voc-Tech College
7377 South Dixie Bee Road
Terre Haute IN 47802
(812) 299-1121

Samuel E. Borden,
Vice President/Dean

Laser Electro-Optics Technology

Occupational Education
Vincennes University
Vincennes IN 47591
(812) 885-4336

Dr. Bill Spence,
Associate Dean

Kentucky

Robotics Technology

Morehead State University
UPO 774
Morehead State University
210 Lloyd Cassity Building
Morehead KY 40351
(606) 783-2419

Dr. Robert Newton

Maine

Biomedical Instrumentation (under development)

Eastern Maine Voc-Tech Institute
354 Hogan Raod
Bangor ME 04401

Davis Robbins

Maine
CAD Program - Machine Tool

Eastern Maine Voc-Tech Institute
354 Hogan Road
Bangor ME 04401
(207) 942-52717
Tim LeTourneau

Commercial Refrigeration

Eastern Maine Voc-Tech Institute
354 Hogan Road
Bangor ME 04401
(207) 942-5217
Clyde Perry

Computer Electronics

Northern Maine Voc-Tech Institute
33 Edgemont Drive
Presque Isle ME 04769
Richard M. Knight

Digital Electronics I Basic; II Advanced

Northen Maine Voc-Tech Institute
33 Edgemont Drive
Presque Isle ME 04769

Electro/Mechanical Technology

Central Maine Voc-Tech Institute
1250 Turner Street
Auburn ME [illegible]4210
(207) 784-2385
William L. Vassar,
Assistant Director

Electronics in Autos (under development)

Eastern Maine Voc-Tech Institute
354 Hogan Road
Bangor ME 04401
(207) 942-5217

Hazerdous Waste Control (under development)

354 Hogan Road
Bangor ME 04401
(207) 942-5217

Hydraulics (under development)

Eastern Maine Voc-Tech Institute
354 Hogan Raod
Bangor ME 04401
(207) 942-5217

Maine

Industrial Electronics

Northern Maine Voc-Tech Institute   Richard M. Knight
33 Edgemont Drive
Presque Isle ME 04769

Microprocessing I Basic

Northern Maine Voc-Tech Institute
33 Edgemont Drive
Presque Isle ME 04769

Microprocessing Interface I & II

Northern Maine Voc-Tech Institute
33 Edgemont Drive
Presque Isle ME 04769

Eastern Maine Voc-Tech Institute   Clyde Perry
354 Hogan Road
Bangor ME 04401
(207) 942-5217

Technical Drafting

Northern Maine Voc-Tech Institute   Richard M. Knight
33 Edgemont Drive
Presque Isle ME 04769

Welding

Eastern Maine Voc-Tech Institute   Reggie Roy
354 Hogan Road
Bangor ME 04401
(207) 942-5217

Massachusetts

Data Processing (under development)

Humphrey Center 75 New Dudley Street Boston MA 02119 (617) 442-5200	Jan McWilliams

Communication Information Communication Project

Greenfield Community College One College Drive Greenfield MA 01301 (413) 774-3131	Dr. Cameron Beavers

Computer Education (under development)

Humphrey Center 75 New Dudley Street Boston MA 02119 (617) 442-5200	Marilyn Gardner

Computer Operation

Middlessex Community College Springs Road Bedford MA 01730 (617) 275-8910	Dr. Frederick Peterson

Computer Programmer

Bristol-Plymouth Regional Voc-Tech School 940 County Street Taunton MA 02780	Daniel J. Saunders
Shawsheen Valley Regional Voc-Tech School 100 Cook Street Millerica MA 01866	John McDermott
Greater Lowell Regional Voc-Tech School Pawtucket Boulevard Tyngsboro MA 01879	F. Nelson Burns
South Middlesex Regional Voc-Tech School 750 Winter Street Framingham MA 10701	George Luoto

Massachusetts
Computer Programmer (continued)

Massachusetts Bay Comm. Col.
50 Oakland Street
Wellesley MA 02181
(617) 237-1100
Dr. John Duerfahrd

Roxbury Community College
625 Huntington Avenue
Boston MA 02155
(617) 734-1960
Barbara Burgess

Northern Essex Community College
100 Elliott Street
Haverhill MA 01953
Dean Margaret Watson

Springfield Tech. Comm. Col.
Armory Square
Springfield MA 01105
(413) 781-7822
Dr. John H. Dunn,
Dean of Faculty

Computer Repair

Humphrey Center
75 New Dudley Street
Boston MA 02119
(617) 442-5200
Ralph Mall

Computer Technologies Sciences Upgrading (under devleopment)

Holyoke Community College
303 Homestead Avenue
Holyoke MA 01040
(413) 538-7000
Dr. Cameron Beavers

Computer Technologies Skills

Berkshire Community College
West Street
Pittsfield MA 01201
(413) 499-4660
Dr. Lawrence Gross

Electronics

Humphrey Center
75 New Dudley Street
Boston MA 02119
(617) 442-5200
Jim Cardonia

Massachusetts
NVAC

Humphrey Center
75 New Dudley Street
Boston MA 02119
(617) 442-5200
Ralph Mall

Project COBS (under development)

Humphrey Center
75 New Dudley Street
Boston MA 02119
(617) 442-5200
Mary Russo

Project S.O.S.

Humphrey Center
75 New Dudley Street
Boston MA 02119
(617) 442-5200
Mary Russo

Radiologic Health Sciences

Springfield Technical Comm. Col.
Armory Square
Springfiled MA 01105
(413) 781-7822
Dr. John H. Dunn,
Dean of Faculty

Robotics I and II

Bristol Community College
777 Elsbree Street
Fall River MA 02720
(617) 678-2811
Dr. Raymond Butts

Robotics Technology

Massasoit Community College
290 Thatcher Street
Brockton MA 02402
(617) 588-9100
Dr. James Yess

Northern Essex Community College
100 Northern Essex Comm. Col.
Haverhill MA 01953
(617) 374-0721
Dean Margaret Watson

Massachusetts
Technical Writer

Middlesex Community College Springs Road Bedford MA 01730 (617) 275-8910	Frederick Viaux

Word Processing

Bristol Community College 777 Elsbree Street Fall River MA 02720 (617) 678-2811	Dr. Raymond Butts
Bunker Hill Community College Rutherford Avenue Charlestown MA 02129 (617) 241-8600	Paul Buckley
Holyoke Community College 303 Homestead Avenue Holyoke MA 01040 (413) 538-7000	Dr. Cameron Beavers
Mt. Wachusett Community College Green Street Gardner MA 01440 (617) 632-6600	Ms. Charmiar Sperling
North Shore Community College 3 Essex Street Beverly MA 01915 (617) 927-4850	Ms. Janice Forsstrom
Northern Essex Community College 100 Elliott Street Haverhill MA 01953 (617) 374-0721	Dean Margaret Watson
Quinsigamond Community College 670 West Boylston Street Worcester MA 01601 (617) 853-2300	Dean Margaret Warson
Roxbury Community College 625 Huntington Avenue Boston MA 02155 (617) 734-1960	Barbara Burgess
Quincy Junior College c/o Quincy Public Schools 70 Coddinton Street Quincy MA 02169	Edward T. Hannon

Minnesota

Automated Systems Technician

Eveleth AVTI
Eveleth MN 55734
(218) 744-3302
Edward Russ, Dir.

Hibbing AVTI
2900 East Beltling
Hibbing MN 55746
(218) 262-3824
William Magajna, Dir.

Duluth AVTI
2101 Trinity Road
Duluth MN 55811
(218) 722-2801
Eldon Johns, Dir.

Aviation Program Development

Thief River Falls AVTI
Highway #1 East
Thief River Falls MN 56701
(218) 681-5424
Orley Gunderson, Dr.

CAD/CAM, Joint Education and Industry

Alexandria AVTI
1600 Jefferson
Alexandria MN 56308
(612) 762-0221
Vernon Maack, Dir.

Electronic Office Systems Technology

Alexandria AVTI
1600 Jefferson
Alexandria MN 56308
(612) 762-0221
Vernon Maack, Dir.

Laser Technology Program Development

Suburban Hennepin AVTI
1820 North Xenium Lane
Minneapolis MN 55441
(612) 559-3535
Gene Jereczek, Dir.

Metrology Program Development

Hutchinson AVTI
200 Century Avenue
Hutchinson MN 55350
(621) 587-3636
Warren Macemon, Dir.

Minnesota
Micro-Computer Joint Education and Business

Mankato AVTI
1920 Lee Boulevard
Mankato MN 56001
(507) 625-3441
John Votca, Dir.

Micro-Computer Repair Programming

Hibbing AVTI
2900 East Beltline
Hibbing MN 55746
(218) 262-3824
William Magajna, Dir.

Robotoics Programming

Minneapolis AVTI
1415 Heenepin Avenue
Minneapolis MN 55403
(612) 370-9400
Donovan Schwichtenberg, Director

Telecommunications Program Development

Dakota County AVTI
P.O. Drawer K
Rosemount MN 55068
(612) 423-2281
David Schroeder, Dir.

Visual Communication Equipment

Staples AVTI
Staples MN 56479
(218) 894-2430
Stanley Edin, Dir.

Word Processing Lab

Winona AVTI
1250 Homer Road
Winona MN 55987
(507) 454-4600
William Hemsey, Dir.

Mississippi

Data Processing Technology		
	Itawamba Junior College 653 Eason Blvd. Tupelo MS 38801 (601) 842-5621	Charles Chrestman
CAD/CAM (under development)		
	Itawamba Junior College 653 Eason Blvd Tupelo MS 38801 (601) 842-5621	Charles Chrestman
Computer Numerical Control		
	Itawamba Junior College 653 Eason Blvd. Tupelo MS 38801 (601) 842-5621	Rannie Barnett, Industrial Coordinator
Electronics Technology		
	Itawamba Junior College 653 Eason Blvd. Tupelo MS 38801 (601) 842-5621	Charles Chrestman
Laser/Electro-Optics Technology (under development)		
	Itawamba Junior College 653 Eason Blvd. Tupelo MS 38801 (601) 842-5621	Charles Chrestman
Secretarial Technology		
	Itawamba Junior College 653 Eason Blvd. Tupelo MS 38801 (601) 842-5621	Charles Chrestman
Robotics Technology		
	Itawamba Junior College 653 Eason Blvd. Tupelo MS 38801 (601) 842-5621	Charles Chrestman

Mississippi

Tool & Die Making Technology

Itawamba Junior College
653 Eason Blvd.
Tupelo MS 38801
(601) 842-5621

Charles Chrestman

New Mexico

Engineer Drafting/Design (CAD)

Northern New Mexico Comm. Col.
Espanoloa Campus
P.O. Box 250
Espanoloa NM 87532
(505) 753-7141

Loren Abercrombie

Laser Optics

Albuquerque TVI
525 Buena Vista, SE
Albuquerque NM 87106
(505) 848-1400

Bob Dorak

Oilfield Technology

Roswell Campue
Eastern New Mexico University
P.O. Box 6761
Roswell NM 88201
(505) 347-5441

Vince Murphy

Water Utilities Technology

Dona Ana Branch
New Mexico State University
Box 3DA
Las Cruces NM 88003
(505) 646-3211

Cynthia Hiers-Robinson

New York

Architectural Technology

Saunders Trade and Tech. H. S. 183 Palmer Road Yonkers NY 10701 (914) 963-4567	Sal Mancini

Avionics Technicians

L. A. Wilson Tech. Center? Grand Blvd. and Lucon Drive Deer Park NY 11729 (516) 586-2466	Arthur Harding

CAD/CAM

Seneca Vocational H. S. 666 East Delevan Avenuie Buffalo NY 14215	Joseph Brunner

Chemical Technology

Saunders Trade and Tech. H. S. 183 Palmer Road Yonkers NY 10701 (914) 963-4567	Tom Ferriola

Computer Repair

Buffalo Voc. Tech. Center 820 North Hampton Street Buffalo NY 14211 (716) 897-2005	Thomas Gerbec

Computer Science

L. A. Wilson Tech. Center 17 Westminster Avenue Dix Hills NY 11746 (516) 0102	Joe Myers, Ass't Dir. Occ. Ed.

Industrial Engineering Technology (Includes Robotic Technology)

SUNY College of Technology 811 Court Street Utica NY 13502 (315) 792-3505	Dr. Louis Gavalti, Dea

New York
Robotics in High Technology

Binghamton City Schools 16 St. John Avenue Binghamton NY 13905 (607) 772-0101	Anthony Renzi

Technical Electronics

Saunders Trade and Tech. H. S. 183 Palmer Road Yonkers NY 10701 (914) 963-4567	Rocco LaPenta
L. A. Wilson Tech. Center 17 Westminster Avenue Dix Hills NY 11746 (516) 586-0102	Joe Myers, Ass't Dir. of Occ. Ed.

Robotics in High Technology

Binghamton City Schools 16 St. John Avenue Binghamton NY 13905 (607) 772-0101	Anthony Renzi

Word Processing

Buffalo Voc. Tech. Center 820 North Hampton Street Buffalo NY 14211 (716) 897-2005	Elizabeth Dougherty

Ohio

Biomedical Engineering

Michael J. Owens Tech. Col.
Oregon Road, Caller #10,000
Toledo OH 43699
(419) 666-0580
Jerry Bryant, Dean
Engineering

Cincinnati Technical College
3520 Central Parkway
Cincinnati OH 45223
Robert Speckert

CAD/CAM

Columbus Technical Institute
550 East Spring Street
Columbus OH 43215
(614) 227-2400
Jackie Marshall

Sinclair Community College
444 West Third Street
Dayton OH 45402
Robert Stemple

CAD/CAM Drafting

Central Ohio JVS
7877 Route 42, NE
Plain Sity OH 43064
Paul Miller, T & I
Supervisor

Computer Repair

Gordon D. James Career Center
1824 Saltsprings Road
Warren OH 44481
(216) 824-2534
John O'Neal, T & I
Supervisor

Alliance City School District
Adult Vocational Education
200 Glamorgan Street
Alliance OH 44601
(216) 821-2100
Joseph C. Smith

Industrial Packaging & Quality Control Technologies

Sinclair Community College
444 West Third Street
Dayton OH 45402
James S. Houdeshell

Ohio
Information Processing

Licking Cty. JVS
150 Price Road
Neward OH 4305
Director of Adult
Education

Intensive Secretarial

Alliance City School Dist.
Adult Vocational Education
200 Glamorgan Street
Alliance OH 44610
(216) 821-2100
Joseph C. smith

Laser Optics

Cincinnati Technical College
3520 Central Parkway
Cincinnati OH 45223
(513) 559-1520
Dr. P. Batra

Micro-Computer Operations

Springfield Clark JVS
1901 Selma Road
Plain City OH 45305
(513) 325-7368
William Shepherd,
T & I Supervisor

Office Specialist

Ashtabula County JVS
1565 St. Rt. 167
Jefferson OH 44047
Director, Adult
Education

Oklahoma

Data Processing

Southern Oklahoma AVTS
(405) 377-3333

Tri-County AVTS
(918) 333-2422

Western Oklahoma AVTS
(405) 390-9591

Eastern Oklahoma County AVTS
(405) 390-9591

Oklahoma

Data Processing (continued)

Central Oklahoma AVTS
(918) 352-2551

O. T. Autry AVTS
(405) 242-2750 or
(405) 234-0193

Caddo-Kiowa AVTS
(405) 643-2387

Francis Tuttle AVC
12777 North Rockwell Avenue
Oklahoma City OK 73142
(405) 848-7747

Oklahoma City AVTS
Marvin York Site
(405) 848-7747

Central Oklahoma AVTS
3CT Citcle
Drumright OK 74030
(918) 775-9119

Gordon Cooper AVTS
(405) 273-7493

Indian Meridian AVTS
1312 South Sangre Road
Stillwater OK 74074
(405) 377-3333

Tulsa County AVTS
Memorial Avenue Campus
(918) 627-7200

Mid-America AVTS
(405) 449-3391

CAD/CAM

Indian Meridian AVTS
1312 South Sangre Road
Stillwater OK 74074
(405) 377-3333

Jim Wilson

CNC Operator

Indian Capital
Route 6, Box 206
Muskogee OK 74401

Louis Lemon

Oklahoma

Drafting & Design

Francis Tuttle AVTC
12777 North Rockwell Avenue
Oklahoma City OK 73142

Industrial Electronic Maintenance/Instrumentation

Kiamichi AVTS
(405) 286-7555

Indian Meridian AVTS
1312 South Sangre Road
Stillwater OK 74074
(405) 377-3333

Industrial Maintenance

Kiaminchi AVTS
B. E. Carney
R. #3 Box 50VT
Idabel OK 74745

Industrial Technology

Indian Meridain AVTS
Jim Wilson
1312 South Sangre Road
Stillwater OK 74074
(918) 377-3333

Francis Tuttle AVTS
Bruce Gray
12777 North Rockwell Avenue
Oklahoma City OK 73142
(405) 722-7799

Central AVTS
John Hopper
3CT Circle
Drumright OK 74030
(918) 352-2551

Laser Technology

Francis Tuttle AVTS
Bruce Gray
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Oklahoma City OK 73142
(405) 722-7799

Oklahoma
Machine Shop

Francis Tuttle AVTC
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Oklahoma City OK 73142
(405) 722-7799

Indian Meridian AVTS
1312 South Sangre Road
Stillwater OK 74074
(405) 377-3333

Tulsa County AVTS
Memorial Avenue Campus
(918) 627-7200

Oregon

CAD

Clackamas Community College 19600 S. Molalla Avenue Oregon City OR 97045 (503) 657-8400	Terrence Shumaker

Robotics

Umpqua Community College P.O. Box 967 Roseburg OR 97470	Sherril Wells, Dean of Students

South Carolina

Data Processing

Lexington AVC 2421 Augusta Highway Lexington SC 29072 (803) 359-4151	Janet Jabs
Keenan High School 3455 Pine Belt Road Columbia SC 29204 (803) 782-4900	Nancy Odum
Lancaster AVC P.O. Box 520 Lancaster SC 29720 (803) 285-7404	Janet Collins

Tennessee

Application of Digital Integrated Systems

Tri-Cities State Tech. Inst.
P.O. Box 246
Blountville TN 37617

Tommy Haws, Dean of Instruction

Automotive Robotics

Nashville State Tech. Inst.
120 White Bridge Road
Nashville TN 37209

Raymond Stone
Grady Jones
Gwyn Tilley
Helen Meador
Joe Taylor

Chemical Technology

Memphis State Technical Institute
5983 Macon Cove
Memphis TN 38134

George Mackie

Chemical Engineering

Knoxville State Tech. Inst.
3435 Division Street
Knoxville TN 37939-2802
(615) 584-6103

Dr. Don McNelley

Computer Accounting/Engineering Graphics

Knoxville State Tech. Inst.
3435 Division Street
Knoxville TN 37939-2802
(615) 584-6403

Dr. Don McNelley

Computer Aided Drafting

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Nashville TN 37209

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Helen Meador
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Computer Programming/Data Processing

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Knoxville TN 37939-2802
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Dr. Don McNelley

Tennessee

Computer Technology

Memphis State Technical Institute 5983 Macon Cove Memphis TN 38134	George Mackie
Nashville State Tech. Inst. 120 White Bridge Road Nashville TN 37209	Raymond Stone Grady Jones Gwyn Tilley Helen Meador Joe Taylor

Construction Engineering

Knoxville State Tech. Inst. 3435 Division Street Knoxville TN 37939-2802 (615) 584-6103	Dr. Don McNelley

Control Principles - Instrumentation

Tri-Cities State Tech. Inst. P.O. Box 246 Blountville TN 37617	Tommy Haws, Dean of Instruction

Data Processing

Nashville State Tech. Inst. 120 White Bridge Road Nashville TN 37209	Raymond Stone Grady Jones Gwyn Tilley Helen Meador Joe Taylor

Electrical Engineering

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Electrical Technology

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Electronic Engineering

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Tennessee

Electronic Technology

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Electronics

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Industrial Technology

Memphis State Tech. Inst. 5983 Macon Cove Memphis TN 38134	George Mackie

Instrumentation Technology

Memphis State Techn. Inst. 5983 Macon Cove Memphis TN 38134	George Mackie

Instrument Analysis I and II

Tri-Cities State Tech. Inst. P.O. Box 246 Blountville TN 37617	Tommy Haws, Dean of Instruction

Linear Integrated Circuits

Tri-Cities State Tech. Inst. P.O. Box 246 Blountville TN 37617	Tommy Haws, Dean of Instruction

Mechanical Engineering

Knoxville State Tech. Inst. 3435 Division Street Knoxville TN 37939-2802 (615) 584-6103	Dr. Don McNelley
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Tennessee
Mechanical Engineering (Continued)

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Mechanical Architectural Engineering

Nashville State Tech. Inst.
120 White Bridge Road
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Helen Meador
Joe Taylor

Microprocessing Digital Assistance

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Micro Computer Assistance

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Metallurgy

Tri-Cities State Tech. Inst.
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Tommy Haws, Dean of Instruction

Organic Chemistry

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Secretarial Science

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Taymond Stone
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Tennessee
Thermo Dynamics

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Word Processing I and II

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Tommy Haws, Dean of Instruction

West Virginia

Civil Technology (Will Include CAD)

Putnam County Vo-Tech
Route 62
Eleanor WV 25070
(304) 586-2127
Leo Arbaugh

Computer Programming (Will Include Repair)

Arch Moore Vo-Tech Center
Route 1
Liverpool WV 25257
(304) 372-9164
Jim Hutton

Machine Shop (Will Include CNC)

Mercer County Vo-Tech
105 Old Bluefiled
Princeton WV 24740
(304) 425-9551
Herley Bailey

Robotics (Incorporated into Electronics)

Fayette Plateau Vo-Tech
300 West Oyler Avenue
Oak Hill WV 25901
(304) 469-2911
Roy Christ

Wisconsin

CAD/CAM

Moraine Park Tech. Inst.
235 North National Avenue
Fond du Lac WI 54935
(414) 922-8611

Fox Valley Tech. Inst.
P.O. Box 2277
Appleton WI 54913

Dick Schmidt (CAM)
(414) 735-5785
Ron Zenke (CAD)
(414) 735-5777

Milwaukee Area Tech. Col.
1015 North Sixth Street
Milwaukee WI 53203
(414) 278-6320

Victor Langer

VTAE District One
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Eau Claire WI 54701
(715) 836-3911

Bob Birchler

Gateway Tech. Inst.
3520 - 30th Avenue
Kenosha WI 53141
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Western Wisconsin Tech. Inst.
Six and Vine Streets
LaCrosse WI 54601
(608) 785-9200

Computer Service Technology

Fox Valley Tech. Inst.
P.O. Box 2277
Appleton WI 54913
(414) 735-5730

Data Processing

Blackhawk Tech. Inst.
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Janesville WI 53545
(608) 756-4121

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John Eid
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Wisconsin
Data Processing (continued)

Gateway Tech. Inst.
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Kenosha WI 53141
(414) 656-6917

Milwaukee Area Tech. Col.
11015 North Sixth Street
Milwaukee WI 53203
(414) 278-6320

Madison Area Tech. Col.
211 North Carroll Street
Madison WI 53703
(608) 266-5050

Northeast Wisconsin Tech. Inst.
2740 West MasonStreet
Green Bay WI 543031
(414) 498-5400

Mid-State Tech. Inst.
500 - 32nd Street, North
Wisconsin Rapids WI 54494
(715) 423-5650

Waukesha County Area Tech. Inst.
800 Main Street
Pewaukee WI 53072
(414) 548-5566

Western Wisconsin Tech. Inst.
Sixth and Vine Streets
LaCrosse WI 54601
(608) 785-9200

Electronics Servicing

Gateway Tech. Inst.
3520 - 30th Avenue
Kenosha WI 53141
(414) 656-6917

Lakeshore Tech. Inst.
1290 North Avenue
Cleveland WI 53015
(414) 543-4183

Wisconsin
Electronics Servicing (continued)

Mid-State Tech. Inst.
500 - 32nd Street, North
Wisconsin Rapids WI 54494
(715) 278-5320

Southwest Wisconsin Tech. Inst.
Bronson Boulevard
Fennimore WI 53809
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Madison Area Tech. Col.
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Madison WI 53703
(608) 266-5050

Western Wisconsin Tech. Inst.
Sixth and Vine Streets
LaCrosse WI 54601
(608) 785-9200

Wisconsin Indianhead Tech. Inst.
Box B
Shell Lake WI 54871
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Milwaukee Area Tech. Col.
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Electronics Technology

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Virgin Noordyk
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Milwaukee WI 53203
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Western Wisconsin Tech. Inst.
Sixth and Vine Streets
LaCrosse WI 54601
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North Central Tech. Inst.
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Wisconsin
Electronics - Computer

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Milwaukee WI 53203
(414) 278-6320

Electromechanical Technology

Fox Valley Tech. Inst. P.O. Box 2277 Appleton WI 54913 (414) 735-5730	Jerry Wolf
Southwest Wisconsin Tech. Inst Bronson Boulevard Fennimore WI 53809 (608) 822-3262	Chet Nowak.
Moraine Park Tech. Inst. 235 North National Avenue Fond du Lac WI 54935 (414) 922-8611	
Lakeshore Tech. Inst. 1290 North Avenue Cleveland WI 53015 (414) 453-4183	Bob Nabors
Western Wisconsin Tech. Inst. Sixth and Vine Streets LaCrosse WI 54601 (608) 785-9200	Bill Welch, Sr.
Milwaukee Area Tech. Col. 1015 North Sixth Street Milwaukee WI 53203 (414) 278-6320	Pete Jushka

Geometric Tolerancing

Lakeshore Tech. Inst. 1290 North Avenue Cleveland WI 53015 (414) 453-4183	Edward Falck

Wisconsin
Histotechnology

VTAE District One 620 West Clairemont Avenue Eau Claire WI 54701 (715) 836-3911	William Boyle

Industrial Engineering

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Moraine Park Tech. Inst. 235 North National Avenue Fond du Lac WI 54935 (414) 922-8611	Roger Gibbons
Lakeshore Tech. Inst. 1290 North Avenue Cleveland WI 53015 (414) 453-4183	Bob Nabors
Northeast Wisconsin Tech. Inst.. 2740 West Mason Street Green Bay WI 543031 (414) 498-5400	

Industrial Welding

Milwaukee Area Tech. Inst. 1015 North Sixth Street Milwaukee WI 53203 (414) 278-6320	Pete Jushka

Lasers

North Central Tech. Inst. 1000 Campus Drive Wausau WI 54401 (715) 675-3331	Marvin Bauseman
Milwaukee Area Tech. Col. 1015 North Sixth Street Milwaukee WI 53203 (414) 278-6320	Vic Langer

Wisconsin
Lasers (continued)

VTAE District One 620 West Clairemont Avenue Eau Claire WI 54701 (715) 836-3911	Bob Birchler
Gateway Tech. Inst. 3520 - 30th Avenue Kenosha WI 53141 (414) 656-6917	
Waukesha County Tech. Inst. 800 Main Street Pewaukee WI 53072 (414) 548-5566	Don Krummel

Laser - Electro Optics

North Central Tech. Inst. 1000 Campus Drive Wausau WI 54401 (715) 675-3331	Joseph Giovanni

Material Handling

Waukesha County Tech. Inst. 800 Main Street Pewaukee WI 53072 (414) 548-5566	Don Krummel

Mechanical Design

Blackhawk Tech. Inst. Route 3, Prairie Road Janesville WI 53545 (608) 756-4121	
Fox Valley Tech. Inst. P.O. Box 2277 Appleton WI 54913 (414) 735-5730	Ron Zenke (414) 735-5777
Gateway Tech. Inst. 3520 - 30th Avenue Kenosha WI 53141 (414) 656-6917	
Lakeshore Tech. Inst. 1290 North Avenue Cleveland WI 53015 (414) 458-4183	

Wisconsin
Mechanical Design (continued)

Mid-State VTAE District
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Wisconsin Rapids WI 54494
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Milwaukee WI 53203
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Moraine Park Tech. Inst.
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Fond du Lac WI 54935
(414) 922-8611

North Central Tech. Inst.
1000 Campus Drive
Wausau WI 54401
(715) 675-3331

Northeast Wisconsin Tech. Inst.
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Greenbay WI 5430371
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Southwest Wisconsin Tech. Inst.
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Madison WI 53703
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Waukesha County Tech. Ins.
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Wisconsin
Mechanical Design (continued)

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(715) 468-2815

Microprocessore I & II, Logic Circuits

Fox Valley Tech. Inst. P.O. Box 2277 Appleton WI 54913 (414) 735-5730	Virgil Noordyk (414) 735-5783

Numerical Control

Fox Valley Tech. Inst. P.O. Box 2277 Appleton WI 54913 (414) 735-5730	Virgil Noordyk (414) 735-5783
Milwuakee Area Tech. Inst. 1014 North Sixth Street Milwaukee WI 53203 (414) 278-6320	

Precision Inspection

Northeast Wisconsin Tech. Inst. 2740 West Mason Street Green Bay WI 54303 (414) 498-5400	John Pogorelc

Programmable Control

Fox Valley Tech. Inst. P.O. Box 2277 Appleton WI 54913 (414) 735-5730	Virgil Noordyk (414) 735-5783

Quality Assurance

Northeast Wisconsin Tech. Inst. 2740 West Mason Street Green Bay WI 54303 (414) 498-6400	John Pogorelc

Robotics

Fox Valley Tech. Ins. P.O. Box 2277 Appleton WI 54913 (414) 735-5730	Virgil Noordyk (414) 735-5783

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Robotics (continued)

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Waukesha County Tech. Inst.
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Word Processing

Western Wisconwin Tech. Ins.
Sixth and Vine Streets
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Fox Valley Tech. Ins.
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Appleton WI 54913
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Milwaukee WI 53203
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VTAE District One
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(715) 468-2815

Appendix C

Topic List - Robotics Technology

The following list represents the type of topics and terms that should normally be included in a Robot Technology Program. Many terms are synonymous. Efforts from within industry to standardize terminology has not been successful to date.

1. accuracy
2. actuators
3. applications
4. arc welding
5. artificial intelligence
6. articulated arm
7. assembly cells
8. assembly robot
9. automatic assembly
10. automation
11. axes of motion
12. axis
13. batch systems
14. branching
15. CAD/CAM
16. capabilities
17. capital expenditure
18. cartesian coordinates
19. chain drive
20. characteristics of Robots
21. classification of Robots
22. classification machine tools
23. closed-loop
24. controller
25. CNC
26. communications
27. compliance
28. computer controlled
29. continuous path
30. controlled path
31. controllers/memory
32. controls for actuators
33. controls/power supplies
34. conveyors
35. cycle time
36. cylindrical coordinate
37. definition of "Robotics"
38. degrees of freedom
39. digital input/output
40. digital tape
41. down loading
42. down time
43. drives-actuators
44. drum memory
45. dynamics
46. economic factors
47. electrical
48. electronic
49. endcoder
50. end of arm tooling
51. end effectors
52. environmental factors in Robot system
53. external reference
54. external tooling
55. feedback
56. fixed sequence
57. fixed rectilinear
58. fixturing
59. fiber optic
60. finger
61. flexibility
62. fluid logic
63. FMS-flexible manufacturing systems
64. force feedback
65. gantry configuration
66. gear reduction
67. gripper mechanisms
68. gray scales
69. group technology
70. hard automation
71. heat exchangers
72. high technology
73. history
74. human factors
75. image processing
76. inputs
77. input/output modules
78. inspection
79. intelligent Robot
80. integrate
81. interface
82. interlock
83. internal rate of return
84. internal reference
85. jointed arm
86. jointed spherical

87. justification
88. justification/economic
89. laser
90. limited sequence
91. limit switches
92. longitudinal track
93. low technology
94. machine tool interfacing
95. magnetic wire
96. management acceptance
97. manipulator
98. manual minipulator
99. maunfacturing cell
100. mechanical configurations
101. mechanical stops
102. mean time between failure
103. medium technology
104. micro-computer
105. micro-processor
106. micro-switch
107. mini-computer
108. modular Robot
109. mono-rail
110. NC
111. non-servo
112. object recognition
113. off-line programming
114. open loop
115. operating environment
116. optical fiber sensor
117. opto-isolators
118. orientation
119. outputs
120. painting Robot
121. palletizing
122. part identification
123. part mating theory
124. pay back analysis
125. pay load
126. pedestal configuration
127. pick-and-place Robot
128. photolites
129. playback Robot
130. pneumatic logic
131. point-to-point
132. power supplies
133. polar geometry
134. proximity switch
135. productivity
135. programmable controller
137. programming methods
138. programming languages
139. program storage
140. quality
141. rack drive
142. RCC
143. rectilinear
144. record/playback
145. relays
146. reliability
147. repeatability/accurace
148. remote compliance center
149. research and development
150. resistance welding
151. resolution
152. return on investment
153. rotating joints
154. safety
155. scrap/quality
156. seam welding
157. sensors
158. sensory function
159. servo
160. servo systems
161. sequencer
162. smart Robot
163. social aspects
164. speech
165. speech recognition
166. spherical coordinate
167. step sequencer
168. standards - JIRA, RIA, OSHA, etc
169. structured light
170. sub-routing
171. system engineering
172. tactile sensing
173. teach
174. teaching mode
175. temperature
176. tool coordinates
177. types of Robots
178. unmanned manufacturing
179. uploading
180. user memory
181. values
182. variable sequence Robot
183. vision
184. voice synthesis
185. worker acceptance
186. work envelope

(From a Presentation by F. Z. Sitkins at the 13th International Symposium Industrial Robots Chicago, Illinois April 1983)